THE JANUARY SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

THE SCIENCE PRESS
LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.

Yearly Subscription $5.00 Single Copies 50 cents

NEW BOOKS OF SCIENTIFIC INTEREST

Handbook of the Heavens. Edited by H. J. BERNHARD, D. A. BENNETT and H. S. RICE. ix + 131 pp. Illustrated. $1.00. McGraw-Hill.

An introduction to the study of the stars for junior astronomers, sponsored by the Junior Astronomy Club of the American Museum of Natural History. Chapters on astronomical photography and the use of the telescope are included. Dr. Harlow Shapley has contributed the foreword.

Anecdotal History of the Science of Sound. D. C. MILLER. v + 114 pp. Illustrated. $2.50. Macmillan.

A record of the history of sound from the time of Pythagoras and Aristotle up to the beginning of the twentieth century when the Acoustical Society of America was conceived, with the author as its president.

Radio Engineering Handbook. Edited by K. HENNEY. Second Edition. v + 850 pp. $5.00. McGraw-Hill.

This is a handbook for the radio engineer containing some fundamental principles of electrical engineering, designing, manufacturing and operating equipment for radio communication. The author emphasizes the practical application rather than the theory of radio.

The Book of the Aeroplane. CAPTAIN J. L. PRICHARD. v + 254 pp. Illustrated. $2.75. Longmans, Green.

This book deals with the construction and the mechanics of the aeroplane and also the necessary ground organization to insure safety in landing and taking off. The author gives a brief history of flying and concludes with a discussion of the future of aeroplanes.

Genetics. H. S. JENNINGS. v + 373 pp. Illustrated. $4.00. Norton.

This book is an attempt to present the fundamental features of genetics. The author presents the facts on which heredity depends, discussing the diversities of the materials with which individuals begin life, before taking up the subject of heredity and variation.

A Textbook of Physiology. W. D. ZOETHOUT. Fifth Edition. 5 + 694 pp. Illustrated. $4.00. Mosby.

The author has endeavored to give the basic facts of physiology in this book designed for students of dentistry and pharmacology as well as the general reader. He has devoted two chapters to diet and vitamins and considerable space to personal hygiene.

Concerning the Habits of Insects. F. BALFOUR-BROWNE. x + 169 pp. Illustrated. $1.50. Cambridge. (Macmillan.)

The object of this book is to describe the life histories of various insects and to explain how these life histories were worked out with a view to inspiring the amateur collector and entomologist to look further into the insect world.

Primitive Land Plants. F. O. BOWER. ix + 658 pp. Illustrated. $8.00. Macmillan.

A treatise on living plants as a result of recent fossil discoveries in which the author has attempted to lay a foundation for the organographic treatment of land plants at large by intensive study of those that are primitive.

The Book of the Seashore. H. J. SHANNON. vii + 281 pp. Illustrated. $3.50. Doubleday, Doran.

This book tells the life experiences of a naturalist on the beach. The author depicts the origin and character of the beach and the struggle of the birds and insects for survival. The foreword is written by Dr. Roy Waldo Miner of the American Múseum of Natural History.

An Introduction to Experimental Psychology. P. F. FINNER. vii + 268 pp. $2.00. Prentice-Hall.

The author attempts to present scientific psychology as an integral part of the field of science. The subject is divided into three parts: The field to be investigated and the scientific approach to its problems; the individual and the group studied experimentally; variable records.

Worlds without End. H. S. JONES. vii + 329 pp. Illustrated. $3.00. Macmillan.

The author endeavors to depict for the general reader the Universe and the place the Earth occupies in it as revealed by astronomical observation. The author is an Astronomer Royal, a title conferred by the King of England.

Outposts of Science. B. JAFFE. vii + 547 pp. Illustrated. $3.75. Simon and Schuster.

A journey to the workshops of our leading men of research to whom the author introduces us and endeavors to show us the accomplishments of each in their respective fields of medicine, genetics, anthropology, vitamins, insects, matter and radiation, astrophysics, weather and galaxies.

Man, The Unknown. ALEXIS CARREL. ix + 346 pp. $3.50. Harper.

The author, a Nobel Laureate, presents his philosophy of life in eight chapters: The Need of a Better Knowledge of Man; The Science of Man; Body and Physiological Activities; Mental Activities; Inward Time; Adaptive Functions; The Individual; The Remaking of Man.

Biography of Percival Lowell. A. L. LOWELL. v + 212 pp. Illustrated. $3.00. Macmillan.

The story of the life and achievements of Percival Lowell, who traveled widely in the Far East and returned home years later to enter into the field of astronomical research where he made valuable contributions. The author, his brother, was president of Harvard University.

THE SCIENTIFIC MONTHLY

JANUARY, 1936

RESEARCH—THE YEAST IN THE LOAF OF AGRICULTURE

By H. A. WALLACE

SECRETARY OF AGRICULTURE

Back of practically every activity of the Department of Agriculture there is a research problem, scientific or economic. This is putting it mildly; sometimes there are a dozen problems, all pressing for solution at once. Yet though research is basic to almost all the many government functions relating to agriculture, it gets only a meager part of the funds used in carrying out these functions, and only a small part of the personnel. In 1932 the appropriation for research, exclusive of payments to states, was 6 per cent. of the total budget for the Department. In 1935, when the budget was, of course, swelled by emergency activities, the appropriation for research was less than 1 per cent. of the total. Of the Department personnel of 45,000, some 7,000 are technical workers, and not by any means all these are engaged in research even part of the time.

The Department's work may be likened to a loaf of bread, of which the smallest part, research, is the yeast that leavens the whole loaf; or to a pyramid standing not on a broad base but on a narrow apex of research. If there is not enough yeast, or if it is of poor quality, the loaf will be only half risen; if the apex of the inverted pyramid is too small, the pyramid will topple over. There is no activity on which we can so ill afford to skimp.

Just the same, even if it is done as economically as possible, with no fancy trimmings or elaborate gadgets, research comes high when there are a great many projects to be covered simultaneously. This is one of the reasons why it must be a government function in broad fields affecting millions of people, such as agriculture.

Is it worth the cost? In 1935, an epidemic of stem rust damaged the wheat crop in North Dakota alone to the extent of $100,000,000. One of the research projects of the U. S. Department of Agriculture is the development of rust-resistant wheats, and in cooperation with the Minnesota Agricultural Experiment Station, a new spring wheat, Thatcher, was recently introduced which is more resistant to black stem rust than any variety ever distributed to farmers. Where Thatcher was on trial in the 1935 epidemic, it came through with flying colors. Here is a case where a single product of research might in a single state save many times the cost of the whole research program, covering all states and hundreds of projects. Over 100 strains of black stem rust are now known, and it is likely that more will be found. Thatcher is resistant to almost all the known strains, but it may prove to be susceptible to other strains in the future. In that case, it will be the job of the scientist to develop another wheat

that will meet the new situation. This kind of work is continuous; there can be no let-up if man is to wage a successful battle against his natural enemies.

Just such savings have been made not once but many times. Hog cholera control is an outstanding example of the large returns research may make on the money invested. Moreover, the results of a given project may reach out far beyond what was originally intended or thought of. When workers in the Department of Agriculture found by patient investigation that the cattle tick was the carrier of tick fever, they had no notion that this discovery—which incidentally saved the cattle industry from a situation that was getting near panic—would blaze a trail along which other researchers might track down such deadly human diseases as yellow fever, malaria, African sleeping sickness, Rocky Mountain spotted fever and nagana, all of which proved to be carried by insect hosts. Such connections as this between one field and another are not uncommon. Research in animal nutrition, for example, is closely associated with research in human nutrition, and has led to important discoveries in that field. One of the fascinating and exciting things about science is that there is no telling where some obscure experiment may lead, or what new vistas it may open up.

I confess, then, that I don't have much patience with those who object to the amount of money spent on research. Some of the expenditure, without doubt, will be money thrown down the well. It never will give any return. And there is no sure way of knowing in advance just what will be worth while and what won't. Some of the most promising and elaborate projects turn out to lead up blind alleys; and contrariwise, some apparently insignificant hunch may bring extraordinarily fruitful results. Until all the basic facts and principles are

THATCHER—THE WHEAT OF THE HOUR!

IN LAST YEAR'S UNPRECEDENTED BLACK STEM RUST EPIDEMIC THIS SPRING WHEAT PRODUCED BY SCIENTIFIC RESEARCH WORKERS PROVED TO BE THE MOST RESISTANT TO THIS DISEASE OF ANY VARIETY YET DISTRIBUTED TO FARMERS.

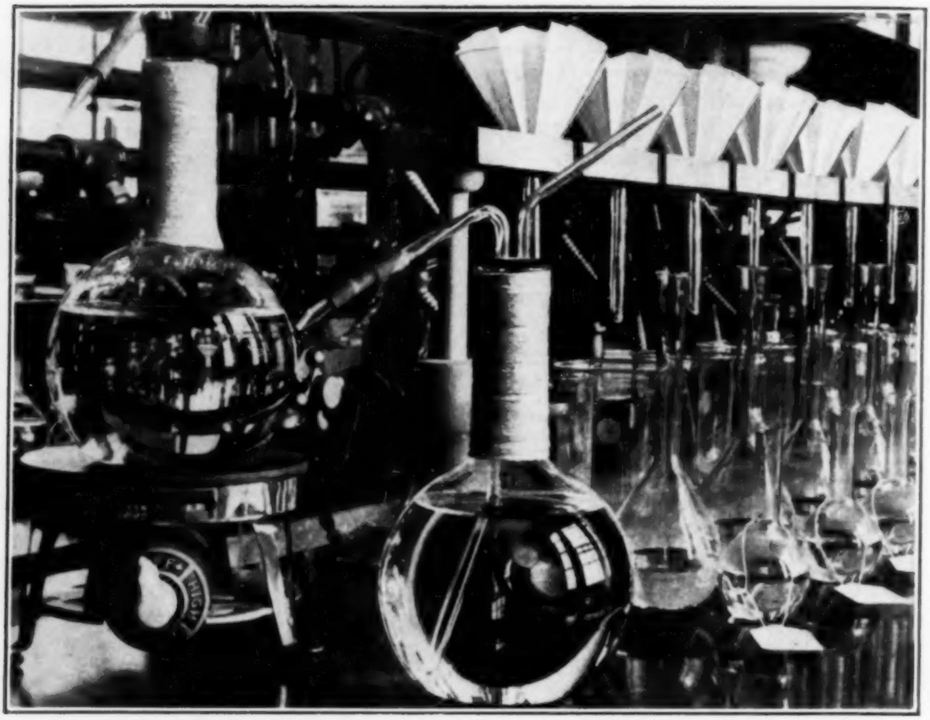
known, research must frequently take a shot in the dark. But whatever may be the outcome in any given project, there can be no doubt that research as a whole pays its way many times over.

This is not to say that it is not possible to waste both money and time in research. Good judgment has to be exercised here as well as elsewhere, even though it is not always easy to know what is ahead of the times because it seems insane, and what is insane because it merely seems to be ahead of the times. Again, equipment may be elaborated to the point where a man is so lost in admiring it that he forgets to think. A research man has to have adequate funds, and the proper tools, and a good reference library, but it is the man himself who counts most. The history of science is full of the stories of men who did brilliant things with nothing to start with but a good brain, plus enough ingenuity and determination to make what they needed out of some odds and ends. Again, it is possible to waste time and money because the research man is so surrounded by administrators, directors and committees, and so wound up in a ball of red tape, routine and regulations, that he can hardly get free long enough to do any work. All these elements are unfortunately necessary in a vast organization such as a federal department, but there must be a constant effort to simplify and cut through the clutter. The research worker in a large organization should be given a definite assignment and made responsible for it, but thereafter he should be bothered as little as possible. I feel that our research men must be relieved of some of the excessive amount of routine correspondence, answering of inquiries, *et cetera,* that now bedevils them.

A Research Roll of Honor

Fortunately, the Department has always been able to attract men of high caliber. I would like to deviate from the subject and talk about that, but this is not the place for it. It is something to think about, however, that so many men and women who are the salt of the earth, if one may judge by hard work and worth-while achievement for mankind, have deliberately chosen, over many decades, to work in obscure government jobs for rewards that in many cases do not compare with what they might have had in private industry. There are motives at least as potent and lasting as the desire for gain, without which, some people argue, progress would stop and men would never do anything.

Since the establishment of the Department of Agriculture in 1862, nearly 75 years ago, there have probably been at least a hundred Department scientists who have gained national and sometimes international fame for their work. In the Bureau of Entomology and Plant Quarantine alone I can think of at least seventeen men of outstanding achievement, including B. W. Coquillett, who developed cyanide fumigation for insect pests; H. G. Hubbard, who developed oil emulsion sprays; Albert Koebele, whose work on the natural parasites of insects has world-wide significance; W. E. Dove, the medical entomologist who discovered that typhus may be transmitted by a certain mite; and F. G. White, investigator of bee diseases. In other fields there are many more who might be added to a roll of honor for their service to mankind and particularly to agriculture —for example, N. A. Cobb, famous for his exact scientific research on nematodes; M. Dorset, who worked out hog cholera serum; W. W. Garner, discoverer of the effect of length of day on the development of plants; Maurice Hall, who developed the carbon tetrachloride and more recently the tetrachlorethylene treatment for hookworm; C. F. Marbut, whose work in soil classification has been outstanding; Cornelius L. Shear, the mycologist who has done so much to enlarge our knowledge of the sac-fungi which



SCIENTIFIC WORK IN AGRICULTURE

HAS BECOME SO REFINED THAT BEST AND LATEST OF LABORATORY EQUIPMENT IS NECESSARY TO SOLVE MANY OF THE COMPLICATED PROBLEMS THAT ARE CONSTANTLY BEING ATTACKED.

cause such serious diseases as chestnut blight; Erwin F. Smith, who discovered that bacteria cause diseases in plants; Theobald Smith, who was in charge of the epoch-making cattle tick fever investigations; and Sewall Wright, whose work with inbred lines of guinea-pigs made notable contributions to animal genetics.

The Department is justly proud of its record as a great research organization, and the credit is due to such men as these and their coworkers. They have left a permanent impress on the Department and exerted a strong influence on other, younger men. If we build still better things on the foundations laid since 1862, as we hope to do, it will be because the Department continues to attract the same kind of ability and the same kind of singleminded service to science.

The Extent of Agricultural Research

The research carried on in the Department of Agriculture not only vitally affects the interests of six to seven million American farm families; it also touches almost every individual in the country in one way or another. Most people think of the work of the Department as being concerned with the production of crops and live stock, but it is by no means exclusively that. There is a wide range of things that affect production or develop logically from it. The building and maintenance of roads; the conservation of soil fertility and the related prob-

lems of managing vast forest areas wisely, and conserving wild life; weather forecasting and study of the effects of weather; the refrigeration, storage, transportation and marketing of farm products; protection of consumers through meat inspection service and food and drug laws; the study of human nutrition so that food production may be linked with the physical welfare of the people of the country; testing and development of standards for various products used by farm families, for whom the government is a consulting service on innumerable problems—these and a great many other activities come within the scope of this Department. Without research, these activities would be crude, fumbling and ineffective.

It is not surprising, then, that there are at least 6,700 specific lines of research going on in the Department of Agriculture at the present time. Exactly how many there are it is impossible to say; there has never been any system for keeping an exact account of the details at a central place, but we are trying to work out such a system now so that at any time it will be possible to know the status of any line. Records are maintained on a broader basis, however, under a recently inaugurated Uniform Project System which groups all regular, continuing research activities into 672 "work projects," and these again into 180 different "financial projects," each covering a broad field of activity. I arrive at the figure of 6,700 specific lines of research because I know from their character that the 672 works projects on the average cover at least ten lines. In the near future we hope to set up "line projects" for each of these specific lines.

This, of course, is quite aside from regulatory and service activities. Although the Department has 15 bureaus, all of which carry on research of one kind or another—for example, Animal Industry, Entomology and Plant Quarantine, Plant Industry, Soil Conservation Service, Weather Bureau, Forest Service, Public Roads, Chemistry and Soils, Agricultural Engineering, Home Economics, Food and Drug Administration, Biological Survey, et cetera—the research activities often cut across strictly administrative lines and come under more than one bureau. This creates a real problem of overlapping, duplication of effort and assignment of responsibility. The Uniform Project System should give a sufficiently clean-cut picture at all times so that this problem may be minimized. But then the other danger must be avoided—the tendency to schedule and regiment research work too closely. To give research work enough freedom so that it is not stifled in any way, but not so much freedom that the scientist wanders all over the lot, is a nice task of administration.

Then there is the problem of getting adequate facilities. Here we are duly grateful for emergency funds which have been made available during the past two years, outside the regular appropriations for the Department. With these funds we have been able to provide new greenhouses and laboratories for fruit work; a laboratory for the study of farm wastes; one for the study of naval stores (primarily resin and turpentine); field stations for cotton breeding; better facilities for the study of spray residues; buildings and equipment for the study of animal diseases; added facilities for research in nutrition and in genetics and breeding; and housing for research workers located at field stations. T total emergency funds used for these purposes during the two years amounted to about $7,000,000. Much more could be spent, but the line must be drawn here between what is actually needed to do a job adequately, and what is desirable but still more or less in the nature of a luxury.

SWEETPOTATO STARCH FACTORY

AT LAUREL, MISSISSIPPI, OPERATED BY THE SWEETPOTATO GROWERS, INC., A COOPERATIVE GROUP OF FARMERS. RESEARCH BY THE DEPARTMENT LED DIRECTLY TO THE ESTABLISHMENT OF THIS PLANT.

The Bankhead-Jones Act—A Major Stimulus

Now, as every scientist knows, one of the major afflictions of the research worker's life is the constant pressure from so-called practical men to get results. By this the practical man usually means something that pays an immediate profit. It takes a considerable acquaintance with the scientific view-point and with the actual achievements of science to realize that the same standards can not possibly be made to apply here as are applied in business.

A familiar example is the development of the airplane by the Wrights. The dramatic and sensational character of the achievement was far more obvious in that case than in most scientific research; but even so, there was a wide-spread feeling that while the contraption invented by the Wrights was interesting, it never could amount to anything from a practical standpoint. Judged by ordinary standards, the Wrights were just a pair of brilliant nuts who might have put their talents to much more practical use than loafing around for days at a time watching buzzards sail gracefully through the air. Out of this watching, however, the Wrights got facts and principles; and these facts and principles not only served as the foundation for a great new industry, but led to the conquest of a new element by man. That could not have been done except by just such apparently dreamy and slightly insane goings-on. The Wrights were not practical in the same sense that a man is when he puts a new gadget on the market and brings in a million dollars. They were merely super-practical.

So the research worker often feels like saying, "For heaven's sake, go away and don't bother me! Maybe what I am doing doesn't look to you as though it were leading anywhere—but fifty years from now you may have a different idea about it!"

This situation constantly arises in agricultural research also. Fundamentally, the Department is concerned with making production better and more efficient, and insuring the preservation and adequate development of America's great agricultural resources—all for thoroughly practical reasons. But to insist that everything done must have an immediate practical aim and that every dollar spent must return an immediate profit is to be blind to the real function of science. In the long run, for example, it may be

as worth while to develop an inbred line of dairy cows that break all records for low production as to be constantly trying to hammer away on better and better production. Conceivably, the low-producing strain might more quickly turn up valuable information on the hereditary factors that influence milk production. Yet to the practical man, this seems like a hind-foremost way to go at the problem, and as far as he is concerned, he won't have his money spent on any such foolishness. He can't quite understand why a research worker engaged on such a problem might feel a tingle in his spine and let out a yell of joy if he finally bred the world's absolutely most useless cow—and succeeded in finding out why.

I don't say that that particular experiment would solve the problem of breeding consistently great milk producers. But unless we are willing and able to make just such a basic approach to a problem whenever that approach seems to be called for, we might as well give up research. And I would add that this basic approach is peculiarly the function of just such an organization as the Federal Department of Agriculture. It can and should be relatively free of immediate pressures. It can and should concern itself with problems that affect the whole country, or great regions, and that are above the conflicting pull of purely local interests. It can and should carry on long-range, long-time projects that may take more than one generation to com-

RECORDING ATMOSPHERIC CONDITIONS

SCIENTISTS REQUIRE ACCURATE DATA ON ENVIRONMENTAL CONDITIONS IN ORDER TO INTERPRET ACCURATELY RESULTS IN THE FIELD.

MODERN HOUSING FOR COWS

DAIRY CATTLE BREEDERS SHOULD BE ABLE TO MAKE GREAT STRIDES IN IMPROVEMENT BECAUSE THEY HAVE TWO RELIABLE YARDSTICKS FOR PRODUCTION—MILK AND BUTTERFAT PRODUCTION.

plete, and that are too costly to come within the means of any unit smaller than a federal department.

This, as a matter of fact, is what the Department of Agriculture tries to do. It has long had the national approach. The regional approach, which considers states in large groups based on homogeneous conditions and interests, is a newer development. It has grown out of the pressing problems faced by agriculture during the depression—problems that necessitated the broadest possible planning, yet planning that would take regional differences into account.

Considered as a whole, then, agricultural research may be said to take in three things—national needs, regional needs and state or local needs. There is no sharp division, of course, and all three needs are likely to overlap, but the triple view-point is useful, particularly from the standpoint of administration.

It has been recognized in what is perhaps the biggest forward step yet taken to stimulate the kind of research I have been discussing in agricultural problems. I refer to the Bankhead-Jones Act, which passed the last Congress as H. R. 7160, appropriating funds, among other things, "for research into basic laws and principles relating to agriculture." Note the words, "basic laws and principles"—they are calculated to warm the heart of the scientist who often finds himself stumped at some vital point because too little is known about the basic laws and principles involved, and there is neither time nor money to follow through the difficult task of tracking them down. The funds allocated by this law are to be divided into three parts: 20 per cent. for

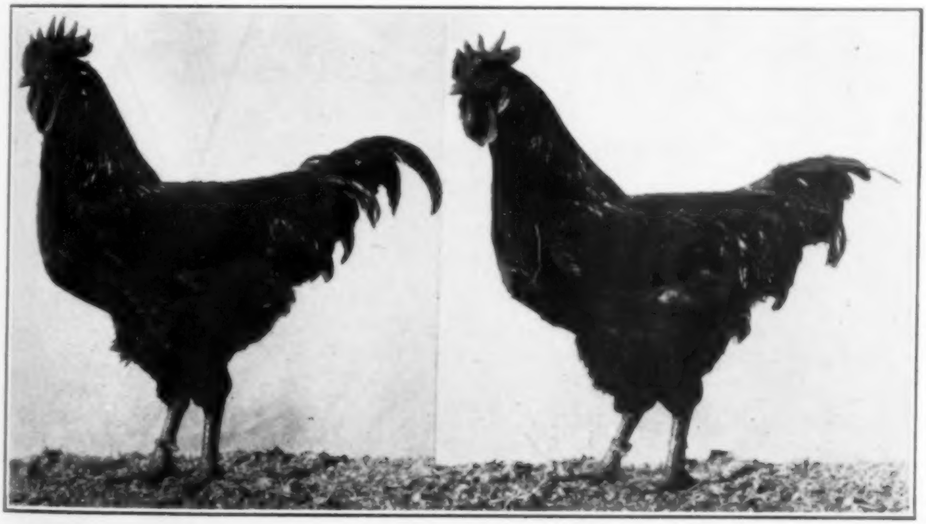
federal projects; 20 per cent. for regional projects, to be planned and carried forward under the direction of the Secretary of Agriculture; 60 per cent. for state and local projects, to be carried on by the 48 state experiment stations, and the stations in Alaska, Hawaii and Puerto Rico.

The use of these funds, then, will involve (1) research of a very broad kind by the Federal Government, including much really basic research; (2) setting up regional laboratories or research centers where the large regional problems—probably those suggested by the state experiment stations, who should have the most realistic understanding of what is needed—can be attacked; (3) continuance of experiment station work, which largely involves the application of the best available scientific methods and knowledge to a wide variety of local problems.

It is not too much to say that the Bankhead-Jones Act is a milestone marking the most complete recognition we have yet had, first, of the prime necessity of research if we are to make progress; second, of the fact that to-day one of the major functions of government is to carry on this research, wherever it may lead, for the ultimate good of all the people. I realize that money and enthusiasm are not, by themselves, enough to ensure a worthwhile outcome; but I feel sure that this kind of approach, this kind of freedom to survey the whole field and follow any problem through relentlessly, and this forthright shouldering of a herculean task by the government—the only organization sufficiently big and sufficiently aloof to take it over—these things, I feel sure, are necessary if we are to get anywhere to-day.

Suggestions for Basic Research

Two kinds of research, scientific and economic, will be carried on under the Bankhead-Jones Act. These will cover (1) research in basic laws and principles, in the broadest sense; (2) research in the marketing of farm products, improved



FULL BROTHER RHODE ISLAND REDS

THEY LOOK ALIKE, BUT THE PROGENY TEST SHOWS THAT THEIR BREEDING WORTH IS ENTIRELY DIFFERENT. DAUGHTERS OF THE BIRD ON THE LEFT AVERAGED ONLY 160 EGGS EACH, WHILE DAUGHTERS OF THE BIRD ON THE RIGHT AVERAGED 206 EGGS.

methods of production and distribution, new uses for products and by-products, et cetera; (3) research relating to the conservation of land and water resources and their best development and use.

How significant a step this is the reader will realize if he looks over the following list. It is a partial list of research problems suggested by various research workers, bureaus and committees as suitable for attack under the first division of the Bankhead-Jones fund—that is, the 20 per cent. assigned for basic research without restriction. Any scientific reader, I think, can not but have his imagination stirred merely by going over this list.

Studies of Plant and Animal Genetics

- Comparative genetics and cytology of a polyploid series—wheat
- Development of a strain of dairy cattle genetically pure—(homozygous) for a low level of milk production as a basis for genetic studies on milk production factors
- Development of indexing techniques to be used in inheritance studies with meat and fiber producing animals
- Linkage of visible characters and endocrine physiology

Animal and Human Physiology

- Physiology of reproduction of domestic animals
- Measures of nutritional status
- Pharmacological and physiological effects of plant constituents
- Physiology of insects

Plant Physiology

- Possible occurrence of plant auximones and hormones and their role in reproduction and general plant physiology
- The mode of action of length of day as a factor in plant growth and development
- Some phases of the chemical photosynthesis of plant substances
- Drought resistance of forest and shade trees

Animal and Plant Pathology

- The interrelationship of virus diseases
- Plant viruses, their nature and properties
- Study of groups of plant parasitic fungi, their taxonomy, physiology, pathogenicity, etc.
- Diseases of insects

Vitamin Studies

- Vitamin requirements of farm animals
- Quantitative evaluation of vitamin effects
- Measures of nutritional status
- Some phases of chemical photosynthesis of plant substances

Enzyme Studies

- Chemistry of enzymes

Studies of Fats

- Nutritive value of butter fat
- Chemistry of rancidity
- Rancidity of fat

Studies of Trace (Rare) Elements

- Trace elements
- Trace elements in natural foods
- Role of the various chemical elements in plant growth with special reference to trace elements

Pharmacology and Chemotherapy

- Pharmacological and physiological effects of plant constituents
- Chemotherapy of animal diseases

Studies of Wood

- Wood substance, its chemical and physical structure and colloidal properties

Agricultural Economics

- The actual as contrasted with the theoretical functioning of competition and bargaining in the marketing of farm products
- Interregional competition in the production and sale of farm products within the United States
- Land-use adjustments in farming areas

Weather Studies

- Development of a scientific basis for forecasting (well in advance) weather conditions during critical growing periods for important crop areas in the United States and competing countries
- Development of a scientific basis of forecasting (well in advance) crop yields per acre
- Investigation of climatic trends and their relation to crop yield trends
- Relations between antecedent pressure, temperature and rainfall in remote regions in the northern and southern hemispheres and temperature and rainfall in the United States

Innumerable problems, of course, might be suggested under the regional and state divisions. Under the regional division, for example, might come the development of improved varieties of

THE PRODUCT OF GENETICS

COLUMBIA RAM DEVELOPED BY THE DEPARTMENT BY CROSSING RAMBOUILLET EWES AND LINCOLN RAMS. IN EIGHT YEARS' COMPARISON WITH PUREBRED EWES OF FOUR BREEDS COLUMBIAS PRODUCED MORE WOOL AND THE LAMBS REACHED A GREATER WEIGHT AT WEANING TIME.

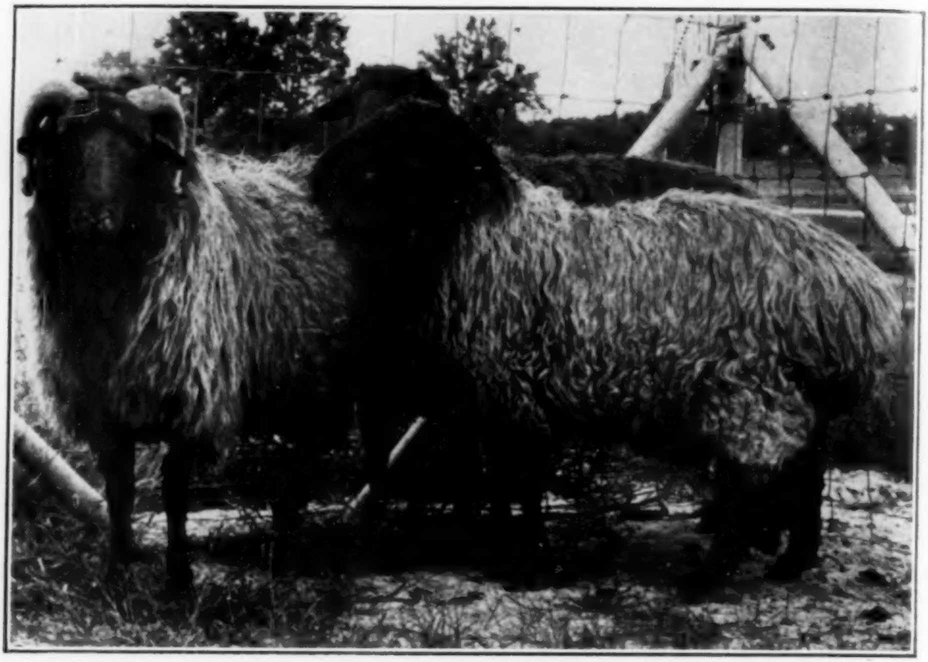
vegetables for the South; beef cattle improvement for the Southwest; research on the economic possibilities of power alcohol from corn, for the Corn Belt.

The last is suggestive of a much-needed approach that should now be possible. We know that power alcohol can be made from corn or other farm products in the laboratory. But what are its commercial possibilities and limitations? This is a matter of controversy and opinion among experts. Only experimental production on a commercial scale, and a sufficiently extended trial, can settle the questions involved. Similarly, in developing starch from sweet potatoes, it was necessary to set up and operate a plant of commercial size in order to put laboratory findings to a practical test. Incidentally, in this case the experiment has met with signal success.

A Survey of Research in Genetics

When it comes to giving an account of the present research work of the Department, the field is so large that I can at best pick out a few of the high spots, a few things that seem to me particularly interesting.

What comes into my head at once is genetics and breeding. Doubtless this is because I have been a corn breeder myself for more than 30 years. The joy and the thrill of the work are in my bones; the golfer making a hole in one gets only



KARAKUL SHEEP

RESEARCH ON LUSTER OF FIBER AND TIGHTNESS OF CURL HAVE DONE MUCH TO IMPROVE THE ECONOMIC STATUS OF THIS BREED.

a mild imitation of the kick the corn breeder gets when something clicks that he has been working on for years. Corn breeding has bigger things ahead, but the degree of progress already made through the fine cooperation of numerous investigators may be judged from the fact that it is now necessary to divide the plant up on a genetic basis and hand out only one group of genes to each investigator. This division was made in 1928, when Dr. R. A. Emerson, of Cornell University, headed what is known as Maize Genetics Cooperation. Under this plan, the genes in corn are divided into their ten known linkage groups, and one man is responsible for research on each group, thus:

Group 1. P-br . . . Dr. R. A. Emerson, Agricultural Experiment Station, Ithaca, New York
Group 2. B-lg . . . G. W. Beadle, Institute of Technology, Pasadena, California
Group 3. a_1-Rg . . . R. A. Brink, Genetics Dept., University of Wisconsin, Madison, Wisconsin
Group 4. su-Tu . . . D. F. Jones, Genetics Dept., Agricultural Experiment Station, New Haven, Connecticut
Group 5. pr-v . . . C. R. Burnham, Agronomy Dept., University of West Virginia, Morgantown, West Virginia
Group 6. Y-Pl . . . L. J. Stadler, Field Crops Dept., University of Missouri, Columbia, Missouri
Group 7. gl_1-ra . . . M. T. Jenkins, Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.
Group 8. j . . . G. F. Sprague, Agricultural Experiment Station, Columbia, Missouri
Group 9. c-wx . . . W. H. Eyster, Botany Dept., Bucknell University, Lewisburg, Pennsylvania
Group 10. R-g_1 . . . E. W. Lindstrom, Genetics Dept., Iowa State College, Ames, Iowa

Unpublished data are quickly exchanged among the investigators. Stocks of all genes and genetic testers are maintained and are available to all the workers in the field. To my mind, this maize genetics investigation stands out as a dis-

tinguished and suggestive example of close cooperation for a scientific end.

The whole field of plant and animal genetics is at present getting intensive attention in the Department because we are in the throes of making up a Yearbook devoted entirely, in its textual matter, to that subject. The story of that effort in itself throws light on the work of the Department. Some time ago a committee was appointed, with O. E. Reed, chief of the Bureau of Dairy Industry, as chairman, to survey what was being done in this field. Scientific readers need not be told that no division of biological science has come in for more intensive effort within the past 35 years than genetics and breeding; the rediscovery of Mendel's work at the turn of the century was an eye-opener comparable to the discovery of vitamins in the field of nutrition, and it stimulated an enormous amount of activity on a world-wide scale; a bibliography of agricultural genetics made by the Department library a few years ago listed over 1,000 titles on wheat alone. But where was all this work leading? Where do we stand? There seemed to be a need for surveying the entire field, summing up what has been accomplished, weighing the practical results, appraising and criticizing, picking out the weak spots, perhaps suggesting fruitful new possibilities. This was the task the genetics committee set for itself.

Admittedly it is no modest task. Admittedly it can only be partially and imperfectly done; it is the kind of thing that calls for continuous effort by a group of men not only thoroughly well informed, but possessed of a peculiar ability to synthesize many lines of work and see the picture as a whole. Partial and imperfect as the results are, however, they turned out to be so interesting that it was decided to devote the 1936 Yearbook to them instead of to the usual miscellany of Department activities. There is good reason for this, in that nothing more vitally affects farmers than the breeding of improved plants and animals, more economical, more productive, better able to withstand the ravages of diseases that sweep like prairie fires through our close-packed modern plant and animal communities. At the same time, the genetic basis for these improvements and the methods employed are not commonly or widely understood. It was felt, then, that such a Yearbook might have not only some practical value, but an educational value of a high order.

As it worked out, the material shook down into two parts. There is first a running account and discussion of genetics and breeding work; second, a survey and actual listing of superior germ plasm in existence for the various classes of plants and live stock discussed. In the 1936 Yearbook there is room for only 19 classes, but these include all the major crops and animals, the wheel horses of agriculture. It is hoped that the 1937 Yearbook may complete the job by covering a wide variety of plants and animals that are economically not quite so important, but perhaps of even wider interest.

Agricultural Aristocrats

These lists of superior germ plasm, compiled from material gathered not only in the United States but, in so far as possible, from all over the world, should constitute a sort of social register or Almanac de Gotha of agricultural aristocrats. (But this aristocracy is based on actual merit, not on name.) The lists will show where superior breeding material is available, and tell concisely why it is superior.

This is where the critical value of such a task comes in. In making, or trying to make, a survey of superior germ plasm in live stock, it was found that for certain broad classes there is little or no material that can be actually considered superior. There are strains that have

A DANISH LANDRACE GILT

ELEVEN MONTHS OLD, IN THE RECENT IMPORTATIONS DESIGNED TO IMPROVE THE MEAT QUALITY OF SWINE. THE LENGTH AND SMOOTHNESS OF SIDE AND DEVELOPMENT OF HAM ARE ESPECIALLY NOTEWORTHY.

become famous, that are in wide demand and that command a premium on the breeding market. But when it comes to appraising these strains from the standpoint of superiority in characters that really matter, economically or practically, we find that we are standing on very unsure ground. In the first place, there is little in the way of standards by which to measure this kind of superiority, which is the only kind that should count. In the second place, such standards as do exist are almost entirely based on conformation, color, type and other show points that make a pretty animal, but not necessarily a useful one. Yet these show points, along with pedigrees, are the ones that guide the breeder, and they are so firmly embedded in tradition that we have come to associate them with merit—which is very much like saying that people with lantern jaws or a prominent nose or royal ancestors belong *ipso facto* to a superior race.

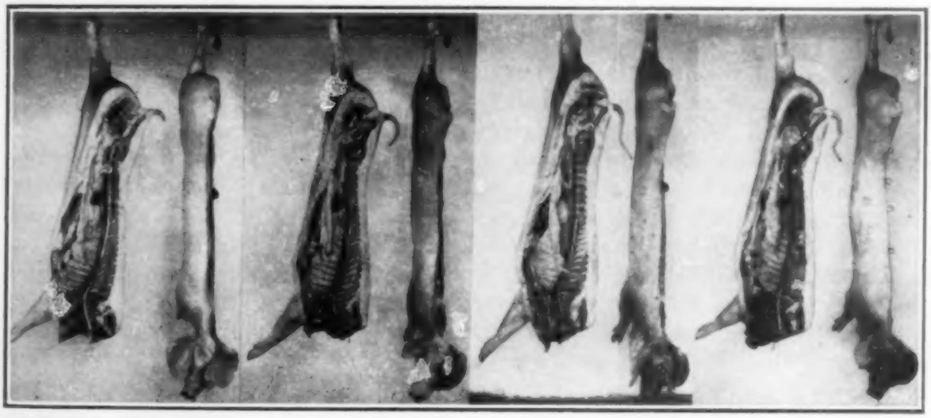
The reasons for this situation, which exists in most live-stock breeding, with the partial exception of dairy cattle and chickens, are too complex to analyze here. They include not only lack of genuinely useful standards and reliance on standards that are superficial if not misleading, but also the cost and the difficulty of experimentation with the larger animals, and the baffling complexity of the genetic factors involved. The net result of all these influences is that animal breeding has not advanced at anything like the pace set in plant breeding.

This is all very well; it may be said that the situation is inevitable. But analysis shows that very little is being done in the way of making a vigorous and direct effort to break the jam. Certain logical possibilities for progress are rather widely accepted by forward-looking animal geneticists, but there is doubt and hesitation in trying these possibilities.

The conclusion reached in the analysis presented in the Yearbook is that animal breeding may be said to stand at the crossroads. If it follows one road, it will become a static art. The other road has at least the possibility of leading to progress. What is involved in following this second road is discussed at some length. The road can not be definitely mapped at the present time, but it is hoped that the discussion will show the urgent need to explore it. Four groups have a vital interest in the improvement of farm live stock: the consuming public (including such groups as the meat packers), the farmer-producers, the professional breeders and the scientists. Logically, the scientists should be the ones to lead the way.

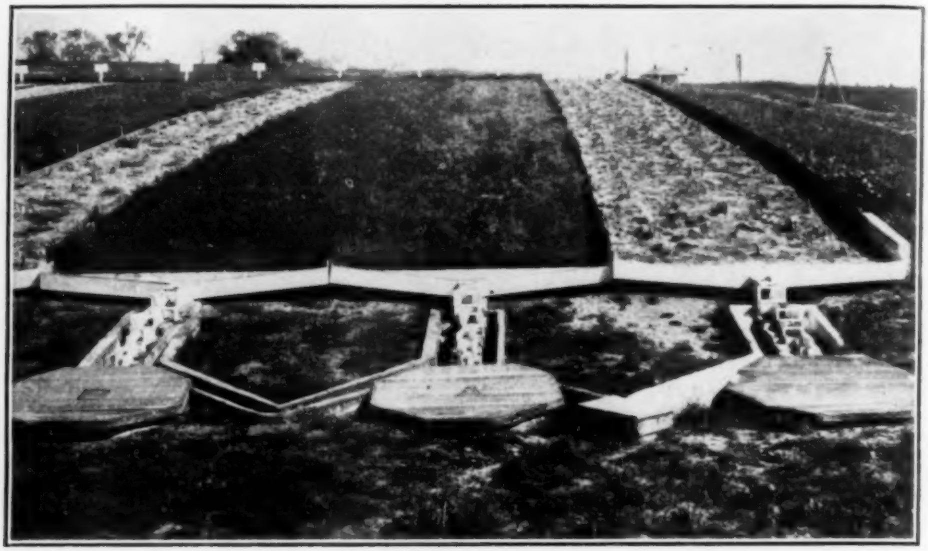
Four recent importations of live stock by the Department of Agriculture are interesting in this connection. Two years ago we brought to this country strains of the famous Danish Landrace and Yorkshire swine, and recently we have made importations of Red Danish cattle and Hungarian Nonius horses (and incidentally of Hungarian sheep dogs, to be used in breeding experiments). Each of these strains is important for characteristics of economic value; the Landrace and Yorkshire swine, for example, have been developed in Denmark for efficient production of high quality bacon, particularly the type known commercially as Wiltshire sides. Experiments will be made with a view to transferring some of these desirable characteristics to our own breeds.

This is a common procedure in plant breeding. Even in plants that have no commercial value in themselves, the breeder often finds characters greatly needed in commercial varieties. By proper breeding methods, he can transfer these characters to the commercial varieties, often without losing any of the desirable traits possessed by the latter. Thus every smooth-awned barley grown in America to-day got this characteristic



CARCASSES FROM FOUR HOGS IN BREEDING TRIALS

FROM LEFT TO RIGHT THEY ARE DANISH LANDRACE SOW, DANISH LANDRACE BARROW, POLAND CHINA × LANDRACE BARROW, AND INBRED CHESTER WHITE SOW. TO DETERMINE THE SUPERIORITY OF THESE ANIMALS CAREFUL DATA ON AVERAGE DAILY GAIN, DRESSING PERCENTAGE, CARCASS LENGTH, PLUMPNESS OF HAM AND CARCASS GRADE WERE RECORDED. FOR EXAMPLE, THE DANISH LANDRACE BARROW MADE AN AVERAGE DAILY GAIN OF 1.86 POUNDS; THE DANISH LANDRACE SOW SHOWED A PLUMPNESS OF HAM OF 186, AS COMPARED TO 124, WHICH IS THE AVERAGE OF 500 HOGS OF AMERICAN BREEDS; AND THE INBRED CHESTER WHITE SOW HAD A CARCASS GRADE OF PRIME MINUS. THIS TYPE OF WORK IS ESSENTIAL FOR IMPROVING OUR MEAT CLASSES OF LIVE STOCK.



MEASURING SOIL EROSION

DEVICE FOR MEASURING SOIL LOSS AND WATER RUN-OFF IN CONNECTION WITH STUDIES OF SOIL CONSERVATION SERVICE AT BETHANY, MISSOURI.

from an obscure strain imported from Russia.

A dip into one of the plant chapters of the 1936 Yearbook will show some of the results of the survey in this field. In the case of wheat, for example, the history of modern wheat breeding is presented in some detail, and the present research work being done in America, and in every foreign country where wheat is at all prominent, is summarized. A report sent in for the survey from Russia, for example, indicates that as a result of systematic collection work, Russian scientists have assembled 31,000 different wheat specimens from all over the world, and the claim is made that, as a result, the number of known botanical varieties —as distinct from agronomic varieties—must now be extended to 650, whereas only 195 botanical varieties are listed in the most complete previous monograph on wheat, prepared in England in 1921.

To help prospective breeders, the names and addresses of the leading workers in each country are given, and there is a similar, more complete directory for each state in the United States. For the United States, all important projects now going on at each experiment station are included. Thus, the information for Minnesota is summarized as indicated in Table I on page 24.

It will be seen that the material in the genetics survey should be of use to those engaged professionally in this field. That, however, is not its only purpose. The primary purpose, in fact, is to present a broad picture, understandable to those vitally interested in American agriculture, of one of the most fascinating and dynamic branches of biological science, and one that is making very great contributions to the well-being of the farmer. The picture should be sufficiently simple so that the lay reader will get an intelligent grasp of what this intensive activity is all about, and see its failures and shortcomings as well as its achievements.

REJUVENATING ERODED SOIL

NOTE GROWTH OF OATS ON NON-ERODED SOIL AT THE LEFT AS COMPARED TO DESURFACED PLOT IN THE CENTER AND DESURFACED AND FERTILIZED PLOT ON THE RIGHT. THESE STUDIES OF SOIL CONSERVATION SHOW THE EFFECT OF EROSION AND METHODS OF "BRINGING BACK ERODED SOIL."

My personal hope is that the account will stimulate many more amateurs to do some experimenting of their own. Over and over again, in the various chapters, the names of amateurs crop up among those who have made notable contributions to plant or animal breeding. Some of these amateurs were not even farmers—but they got the genetic bug, a bug whose bite produces a benign fever calculated to make a man forget his troubles.

A single kernel of wheat may produce 2,000 progeny by the next generation. If that kernel was the hybrid product of a cross, the progeny in the segregating generation may show hundreds of new combinations of characters. And those hundreds of combinations can be produced in a back yard. There are possibilities here that might occupy a man's spare time for years.

Research and Soil Conservation

Four other broad examples may be given here of the research activities of the Department as they tie in with the work of various divisions and bureaus. Three of these deal with the three large conservation bureaus.

First, Soil Conservation: Conserving the productivity of our agricultural lands involves a whole series of complex problems. The first thing is to safeguard the physical body of the soil. Renewal of plant nutrients by the application of fertilizers and through cultural practices is worth while only if the integrity of the soil is maintained. When the soil itself is lost through erosion by wind or water, continued cropping becomes self-destructive or suicidal.

The Erosion Reconnaissance made by the Soil Conservation Service in 1934 showed that wastage of soil resources within the short period of occupation of our country by the American people has been proceeding at a disquieting rate. An area approximately the size of the State of Kansas has been ruined for further cultivation by gullying of cultivated fields. Possible uses left for such

FOREST FIRE RESEARCH

OBSERVATIONS ON THE BEHAVIOR OF FOREST FIRES UNDER CAREFULLY MEASURED CONDITIONS LEAD TO MORE EFFICIENT PROTECTION.

devastated lands are restricted to rough pasture or protection forests. It was discovered, furthermore, that original soil profiles have been truncated by sheet erosion over great areas. Fully 190 million acres have lost more than half of the original topsoil, chiefly by water erosion, and about 9 million acres have been practically ruined for further cultivation by the loss of wind-blown soil, or by the accumulation of hummocks because of wind erosion.

It was found that the good lands of the nation have been occupied and that for the most part they have been cleared and cultivated. Only 75 million acres of the 365 million that have been used for food and fiber production were found to be level and little subject to erosion. The basic fact, then, is that agricultural production must depend chiefly upon the cultivation of sloping lands, and these are the lands that are subject to the ravages of water erosion.

Soil erosion was recognized by the National Resources Board in its report to the President in 1934 as a physical crisis in land use. The rate of soil wastage under modern agricultural technique calls for the development of control measures more promptly than they can be developed by the tedious trial and error method of former times. Only systematic experimental investigations into the character of the factors involved, and into methods for the prevention and control of erosion, will enable us to find a prompt solution to the problem involved in the sustained use of cultivated lands. In short, the principles of scientific research must be applied here exactly as in other important problems confronting agriculture.

Research in erosion control requires the synthesis of a number of divisions of science, since erosion is a complex phenomenon. Its character must be fully identified and its trends charted. As a geologic process, erosion is older than the most ancient sedimentary rocks; it has

sculptured landscapes and supplied materials for vast sedimentary deposits since Proterozoic times. Yet within regions enjoying a climate that supports a complete coverage of vegetation, this geologic erosion has not normally proceeded at rates faster than soil formation. Under such conditions, soils and natural vegetation have developed through thousands of years, each depending on the other. On the other hand, when the natural coverage of vegetation is removed by whatever cause, as by clearing for cultivation, the soils are bared, as they had not been before, to the direct action of wind and flowing water. Erosion of an entirely different order, man-made and accelerated, is thus introduced by agricultural operations. This kind of erosion proceeds at rates much faster than soil formation, and the ultimate destruction of the soil is inevitable.

Acceleration of erosion by flowing water arises from reduced absorption of rain by the soil, and it occurs chiefly on sloping lands. Rates of erosion are dependent on a wide range of factors, and they vary from field to field, from slope to slope and from region to region. Climate, soil characteristics, slope gradients and methods of land use all have an effect. All these elements must be studied and evaluated if we are to develop measures for sustained land use.

Two major types of investigations, exploratory and experimental, are included in the necessary research.

Exploratory investigations comprise surveys and preliminary experimentation to discover the nature and extent of erosion wastage and its effects on eroded

STUDIES OF ROOT SYSTEMS

AID IN SELECTION OF PROPER SPECIES TO FAVOR IN SILVICULTURE AND PLANTING.

FOREST TREE NURSERY

FERTILIZER AND NUTRITION STUDIES IN FOREST TREE NURSERIES POINT THE WAY TO BETTER SURVIVAL AND GROWTH OF PLANTATIONS.

fields, stream channels, storage reservoirs and flood control. These investigations include such erosion reconnaissances as the one made in 1934 by the Soil Conservation Service in cooperation with the state experiment stations; detailed surveys of the nature and effect of erosion on agricultural communities; and surveys of the condition of the storage reservoirs of the nation, such as the one that has been under way for a year.

Experimental as distinct from exploratory investigations involve thorough analysis of the factors of soil conservation region by region, and an experimental evaluation of the factors concerned in soil and water losses under various conditions. They also involve actual experimenting with practices and measures for prevention and control. A beginning has been made in the 10 erosion experiment stations established in 1929. Studies carried on in each region disclosed startling losses in eroded soil

TABLE I

MINNESOTA, Experiment Station, University Farm, St. Paul.

WHEAT BREEDERS:

Early workers: W. M. Hays, Andrew Boss, A. C. Arny, C. P. Bull, E. M. Freeman, A. G. Johnson, J. H. Parker, O. S. Aamodt.

Present workers: H. K. Hayes, E. C. Stakman, E. R. Aucemus, R. H. Bamburg.

BREEDING METHODS:

Commercial Varieties	*Promising New Strains*
Introduction (1888–1935): *Marquis*, Ceres. *Selection* (1902–1935): Haynes Bluestem Minn. 169 (1899), Glyndon Fife Minn. 163, (1899), Mindum, (1917) *Hybridization* (1902–1935): Hard Red Winter Minturki (1917) Soft Red Winter Minhardi (1917) Hard Red Spring Marquillo (1929) Thatcher (1934)	*Hybridization:* *Winter* Minturki × Marquis Minn. 2616, C. I. 11501 Minard × Minhardi Minn. 2313, C. I. 11656 *Spring* Double-cross Minn. 2315, C. I. 10020 H-44 × Marquis Minn. 2634, C. I. 11643

Present work: Winter wheat—Minhardi, Minturki and Minard, crossed together and with Marquis, Hope and H-44 to obtain hardy winter varieties improved in quality and resistant to stem rust.

Spring wheat: Marquillo, Thatcher and other hybrid selections crossed with Hope and H-44 to obtain greater resistance to stem rust, leaf rust and bunt.

and in water as surface runoff. Topsoils under clean-tilled crops were found to be wasting away so that they were lost completely within less than a generation. Crops in usual rotations reduced this rate of soil loss, but they have not been found adequate to safeguard soils on sloping lands for continued cultivation. It became apparent that there is a maximum slope gradient which varies with soil type and that any cultivation on gradients greater than this is unsafe. Close-grow-

ing crops and forage crops gave the greatest protection against erosion.

Where Action Must Precede Research

Such facts must be established for each important agricultural region as a necessary preliminary to researches in methods of prevention and control. The research worker finds that he must take into account regional variations in climate, slope, soil type, vegetation and faunal responses. The study of prevention in regional research centers include agronomic measures (rotations, strip cropping), cultural practices (contour cultivation), and engineering structures (terraces, check dams), and their adaptability and practical application to the several farming regions of the nation. The perfect solution might be level terracing, such as was practiced by the Incas, but it is at least open to doubt whether modern Americans would ever be ready for that.

It would be national folly to let our good lands continue to be wasted when measures for their protection may be discovered and applied. As long as major crop production must be on sloping lands, the objective of the Department of Agriculture, in cooperation with state and other agencies, is to establish methods and practices that will make sustained cultivation safe.

Along with the task of saving the good land of the nation from continued wastage goes the task of rehabilitating and rebuilding soils that have been severely damaged by sheet erosion, reclaiming areas ruined for further cultivation by gully erosion, and restoring vegetation on those parts of the great plains that have been badly damaged by wind erosion. Vegetation is man's chief ally in such tasks. Only a beginning has been made in the selection and use of suitable plants and combinations of plants, native and exotic, for this purpose.

In this brief outline I have attempted only to point out some of the factors involved in soil conservation research—chiefly those factors about which too little is now known. But enough is known to stop many suicidal practices, based on short-sightedness, haste, ignorance, selfishness and economic pressure. There is an intense practical need to stop many of these practices immediately, long before everything is known that will be known about soil conservation. Not everything is known about icebergs, but it is certain that a ship has to be put in reverse when an iceberg looms up ahead. This is what is now being done in agriculture. In the Agricultural Adjustment program, major emphasis is laid on Soil Conservation and better use of land, and many of the features of the program are aimed directly at the elimination of wasteful practices. These features, I think, are here to stay. As fast as science makes available new knowledge and

MODERN FORESTRY

Thinning and pruning experiments determine the possibilities of improving the quantity and quality of forest products.

sound techniques, they too will be put to practical use. Meanwhile, I am glad to say, American farmers show a spontaneous interest in the soil conservation aspects of the program, and a desire to stop practices that lead to the deadly waste they see under their own eyes.

Forest Service Studies All Factors—Biological, Physical, Economic

The forest research program of the Department, centered largely in the Forest Service, is another example of research designed to supply the fundamental technical knowledge without which an objective can not be worked out intelligently or have anything approaching permanence.

The handling of forest lands and the manufacture and utilization of forest products are intimately associated with fundamental problems of social and economic rehabilitation. This requires the application of the idea of timber cropping for sustained yield.

The objective of the Department's activities in the forestry field is to facilitate this rehabilitation, and to bring about a situation under which all the forest land in the United States will make its maximum contribution to economic and social welfare. In this the whole range of biological, physical and economic factors are directly concerned —biological in the growing of the forest crop, physical in its manufacture and utilization and economic in stabilizing the entire forestry enterprise and the communities dependent on it.

Put in another way, this research program is designed to supply the technical foundation for the administration of the national forests; coordinating the submarginal land program of the AAA with the acquisition of public forest lands; cooperative development of state forestry; stimulation of forestry on private lands; and the intelligent use of forest, brush and range cover in watershed protection.

This is an enormous and intricate field affecting directly more than one third of the land area of the United States; a thousand tree species; a wide variety of forest type combinations; climatic variations from the semi-desert to the heavy rainfall of the fog belt, from the tropics to the sub-alpine, and from sea level to 11,000 feet. The soil variety and producing capacity are equally varied, as are the social and economic problems involved.

The forest research of the Department is organized to supply the basis for reforestation; for improving, through plant breeding and cultural practises, the quantity and quality of timber growth; for protecting and maintaining

NATURAL MARSHLAND MOST PRODUCTIVE

EXTENDED RESEARCH BY THE BIOLOGICAL SURVEY COVERING MANY MILLION ACRES OF MARSHLAND HAVE SHOWN CONCLUSIVELY THAT THE NATURAL PLANT FOOD PRODUCTS DEVOTED TO PRODUCTION OF WATERFOWL, AQUATIC FUR-BEARERS AND OTHER WILDLIFE USUALLY GREATLY EXCEED IN VALUE THE AGRICULTURAL CROPS THAT CAN BE PRODUCED WHEN SUCH AREAS ARE DRAINED.

forest cover where it is needed for recreation, watershed protection or wildlife; for investigating the replanting or revegetation of depleted ranges and the intelligent handling of forest and other range lands, with a view to maximum forage production consistent with soil protection and the prevention of erosion; for reducing waste, increasing the utility and satisfaction of forest products to the consumer, and creating new and useful products from wood; for dealing with the financial aspects involved in forest land management, the production and utilization of forest products, present and potential forest-producing capacity, and prospective forest requirements; and for investigating the effect of forest cover and wild-land vegetation on water supply, erosion prevention and climatic and environmental conditions generally.

For efficient administration and correlation, this research work is carried on by 12 regional forest experiment stations, some located so as to collaborate closely with land-grant colleges; and by the Forest Products Laboratory, a national institution associated with the University of Wisconsin where forest products research is centered.

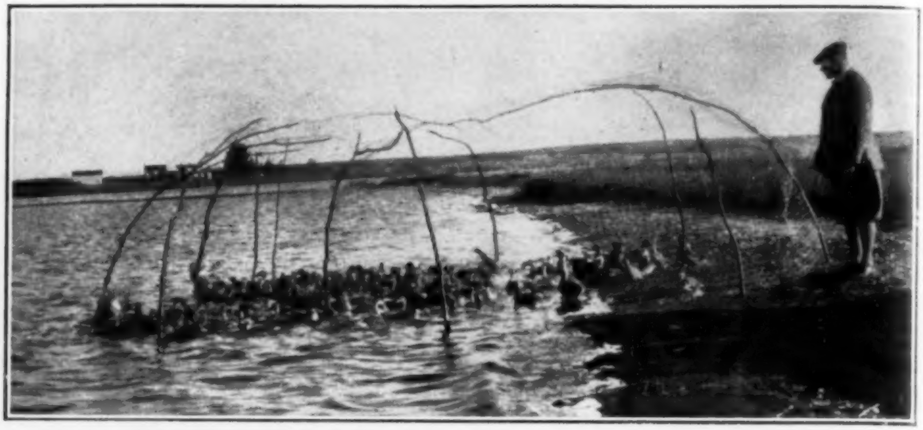
Since forestry deals entirely with growing plants, many of its detailed problems are exactly like those met with elsewhere in agriculture—problems in disease and insect control, plant breeding, adaptability of plant crops to soil and climate, and so on. Interesting in this connection is the work at the Eddy Tree Breeding Institute at Placerville, California, recently taken over by the Department. Here an experiment in breeding trees with superior germ plasm was started by private initiative in 1926. It is an excellent example of long-time research that is bound to give results; and the fact that it could not be continued under private auspices is another instance of the fact that such long-time

AN IMPORTANT FUR-BEARER

RESEARCH HAS DEFINITELY DETERMINED THAT THE NORMAL BREEDING SEASON IN MARTENS OCCURS DURING THE SUMMER MONTHS, USUALLY BETWEEN THE MIDDLE OF JULY AND THE THIRD WEEK IN AUGUST, AND THAT THE GESTATION PERIOD RANGES FROM 8½ TO 9 MONTHS (259 TO 275 DAYS) INSTEAD OF 60 TO 102 DAYS, AS HAS BEEN HERETOFORE BELIEVED.

projects can hardly be carried on except by governmental agencies.

Already the information gathered at this breeding nursery has had a marked effect on timber practises. The Forest Service has changed its ideas in regard to the pine—ideas which should furnish the seed stock for replanting these areas. Also, some attractive new types of tree hybrids have been developed. For example, the Monterey pine, possibly the fastest growing of any of the pines in its early youth, is not very resistant to frost and is therefore limited in its use. However, crosses between the Monterey and the Knob-cone, a type found on scrubby



MIGRATORY WATERFOWL TRAPPED FOR BANDING PURPOSES

RESEARCH BY MEANS OF NUMBERED BANDS IS FURNISHING THE VITAL INFORMATION NECESSARY FOR THE PROPER CONSERVATION AND ADMINISTRATION OF THIS WILDLIFE RESOURCE.

land and extremely frost-resistant, have produced new types which possess the desirable characteristics of both parents, that is, they are both frost-resistant and fast-growing.

New Program in Biological Survey

Wide-spread interest is being shown in the plans of the Biological Survey to set up, in cooperation with the land-grant colleges and other agencies, a far-sighted program in the important field of wildlife restoration and maintenance. The seemingly limitless wildlife resources of North America have been dissipated, despoiled of suitable habitat and slaughtered as the settlement and development of the country progressed. Such effort as there has been in the direction of improving conditions has been handicapped and rendered largely ineffective by lack of biological information and knowledge of the correct principles to apply in practise. As a result, wildlife conditions have gone steadily from bad to worse in recent years.

The new program is designed to meet these issues squarely and effectively. Careful study has been made of the major ecological regions of the United States as a basis for selecting locations. The program of research, demonstration and education will be tied in with 9 land-grant colleges, including their agricultural experiment stations and extension services. The active cooperation of state game departments or conservation commissions has been enlisted, and the recently organized American Wildlife Institute, a continental agency devoted to wildlife restoration, is giving financial aid. Problems representing the more important wildlife species of game and fur-bearers are being selected for research, which will be conducted by experts assigned by the Biological Survey and the colleges, including picked graduate students who will be given theoretical training, guidance in fact-finding and research and practical experience in wildlife management.

Research and practical field demonstrations will be conducted on representative areas of federal, state and privately owned lands. The demonstrations will be based on the research findings applied to improved land and wildlife management

practise and will thus enable land owners and public officials responsible for land use to observe results in actual field operations. In connection with this research and demonstration program, the colleges will give undergraduate courses of instruction leading to degrees in the wildlife management field. Extension activities will bring essential features to public attention and encourage land owners and 4-H Club workers to make use of the available information and to adopt sound wildlife production practises in their use of land, marsh and water areas.

Long-Range Weather Forecasting

One of the major services conducted by the Department of Agriculture is weather forecasting. The fact that weather can not be forecast long in advance is a major handicap in farming and many other operations. Nearly everybody is interested in long-range forecasting, but so far there has been little in the way of tangible results.

Apparently there are several approaches to the problem, and various institutions are working at it from different angles—oceanography, solar radiation, air mass analysis, electromagnetic phenomena, the study of conditions in the polar regions, *et cetera*. Few scientific problems are more truly worthy of a vigorous and concerted attack by every agency that can make any genuine contribution.

To supplement the work that is being done elsewhere, the Department of Agriculture is doing two things.

(1) The Weather Bureau has compiled extensive records from 60 stations throughout the world to see whether variations at any of these stations precede, by one or two or three seasons, variations in any one or more of 12 districts in the United States. These records go back 60 to 100 years, and the effort is to see whether they fall in patterns that might give a clue to conditions that might be expected the following year, or even farther ahead than that. Even if the results are negative, a thorough examination of this field should make it unnecessary for other investigators to go over the same ground.

(2) In the Bureau of Agricultural Economics, in cooperation with the Weather Bureau, a research project is being carried out to determine the possible effect of solar and planetary influences on weather, and to study cycles and lag-correlation in temperature and rainfall in the various states, with special reference to crop forecasting. Once these possibilities have been explored, the Department will be in a position to take up other suggestions.

SCIENCE ADVISORY SERVICE TO THE GOVERNMENT

By Dr. KARL T. COMPTON

PRESIDENT OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY AND CHAIRMAN OF THE SCIENCE ADVISORY BOARD[1]

In his book, "The Advance of Science," Mr. Watson Davis has estimated the total national expenditure for work in science by government, industry, foundations and universities combined to be of the order of one hundred million dollars per year. Of this amount, roughly one third appears in the budgets of the scientific bureaus of the Federal Government, and roughly one third each is expended by universities and industries. Because of the difficulties in defining scientific work and of securing data on comparable bases, these estimates can only be considered to represent the orders of magnitude. They do, however, give an idea of the dollar value which the general public places upon the scientific work which forms a basis for its future welfare.

In comparison with the total national budget, the expenditures for science are an exceedingly small item. Scientific work of the government accounts for considerably less than half of 1 per cent. of the Federal budget. The total national expenditure for science amounts to something like the cost of a half-dozen warships. Altogether it amounts to about one cent out of every five dollars of the total national income. On the other hand, it is this scientific work which has brought about our present standard of living and which is basic to our opportunities for future betterment in health, industrial and agricultural prosperity, and in avoiding those misfortunes which will otherwise inevitably beset us with the exhaustion of certain natural resources.

In this public service of science and scientists, the government, of necessity, plays a rôle whose importance to the country is far greater than the proportionate amount of interest and support which it customarily receives from the occupants of political office. Fortunately, however, there have been, from time to time, public administrators of great vision who have realized the immediate services and ultimate values of scientific work and have brought about the establishment of various scientific bureaus. Fortunately also these bureaus have attracted a great group of able and loyal public servants without whose cooperative effort a great and complex country like ours would utterly fail to function. They advise us regarding the weather, maintain consistency in our technical and manufacturing standards, aid and advise the farmer, maintain the safety and improve the quality of transportation, maintain our health and in innumerable ways aid every group of our population. To quote from the second annual report of the Science Advisory Board:

> In a democracy like ours, designed to safeguard personal liberty and to stimulate individual initiative with the framework of "general welfare," there is no need for the Government to embark upon comprehensive programs in pure science, invention or industrial development. There are, however, numerous scientific services of such wide scope and universal utility that no agency except the Government is competent

[1] In this article the author draws freely from the experience and studies of the Science Advisory Board and the ideas of his colleagues, but he takes personal responsibility for such opinions as are here expressed in regard to the organization and functioning of a Science Advisory Service to Government.

adequately to handle them. There are other scientific services which are essentially supplementary to non-scientific governmental activities. There are also fields of scientific or technical development which hold evident promise of benefiting the public but which are not proper or practical fields for private initiative. In these three categories and in this order of importance lie the proper scientific activities of the Government.

The first scientific bureaus to be established had to concern themselves but little with the coordination of their programs. Each filled a definite need and its purpose was to gather facts in a designated field. Each one was organized because of clearly recognized national opportunities. The several fields of science are now rather fully represented by bureaus. This has led to duplication of effort because the boundary lines between fields of science have tended to grow indistinct. We now talk much more about the borderlands of science. Side by side with the growth in the number of bureaus and in the multiplicity of their functions, there should have been applied the principle of coordination of related work, no matter in what bureaus the work may be done.

Freedom of scientific work from political or policy-making influences is a second prime consideration. It is not our function to appraise national planning by federal agencies or express an opinion on it. Whatever the trend of social or political thought and whatever the degree of national planning, the people of the country have the right to expect that the scientific services are always free to report and interpret the facts in a given field of enquiry as they find them and not as the government of the day may wish to have them reported or interpreted.

Over and above the work of particular scientific bureaus, there is increasing activity on the part of the Government in undertaking large projects whose feasibility or justification are matters for technical decision from many points of view: scientific, economic, humanitarian. Examples of such projects are: irrigation, power development, flood control, soil erosion control, shelter belt, waterways, retirement of sub-marginal land and colonization. Where huge sums are involved and large groups of people affected, it is more than ever necessary that decisions and policies should be settled only after the most thorough, competent and disinterested study of such questions as: Is the project technically feasible? Will it accomplish its purpose? What are the alternatives, and has the best plan been selected? Will the benefits justify the expenditure? For technical advice on such questions, Congress and the Executive Departments should have ready access to, and should use, the best talent available both within and outside of the government services.

In an economic and social structure of growing complexity which we witness everywhere to-day, government, either federal or local, must of necessity assume a more positive rôle than was required in a simpler civilization. The extent of these new responsibilities is one of the most important questions of our times, but it is reasonable to assume that the guiding hand of government will not be relaxed in the future. With government in the stage of transition from the more passive and regulatory part played in the past, to one of more intelligent and broad supervision and initiation, it is the concern of every citizen that there be available to government the most competent and impartial advice which can be found. The endurance of our traditional form of government will depend in increasing measure upon the quality of expert judgment, tempered with experience, which is available to government, and the willingness of government to follow such judgment.

The people of the country thus have a vital interest in the essential scientific services of the Government. It is to the people that the Congress and the Administration are responsible for the effective and efficient operation of these services. It is, therefore, both proper and essential that the scientific personnel of the country, outside the government bureaus, should take an active and cooperative interest in seeing that the scientific work of the Government is conducted in such manner as to render the necessary services effective from the standpoint of science and efficient from the standpoint of management. In science, as in other fields, "to omit from the councils of men any sources of wisdom, judgment, or experience, or to ignore the normal aspirations of any group in the determination of public policy, is to rob society of some of the quality it might possess."

The scientific work of the government can not be maintained on a plane of high efficiency, and have the scope that the national welfare demands, unless the best civilian as well as official judgment is applied to the problems of the several bureaus and their personnel. Congress has both the right and the duty to determine the worth of the scientific bureaus and make appropriations for their support. But in arriving at such a determination the individual members of Congress and the appropriate Congressional committees need to call upon disinterested civilian judgments outside the bureaus and not rely wholly upon the advice and information presented by the

bureau officials concerned. When the latter are efficient and broadminded, as most of them are, little more than confirmation of judgment and opportunity for helpful discussion may be contributed from outside sources. But neither the existing methods of selection and appointment of bureau chiefs, nor the coordination of their work, has reached the point of desired efficiency. It is a commonplace that projects are not always dropped when completed; that coordination is not always welcomed; that personnel is not always as alert and competent as it should be; that duplication of effort amounts in some instances to a disease; that the effective relation of governmental to non-governmental agencies is not a lively concern of some scientific bureaus; that the best advice is not always sought in the public interest; and that the better judgment of bureau chiefs can not always stand up, unaided, against political pressure for certain programs and expenditures.

Still more important, in the long run, is guardianship by scientific men outside the government lest the scientific bureaus be used for political ends. As fact-finding agencies the scientific services should be free to produce results that are not discolored by the opinions and snap judgments of policy-making political groups who may wish to put the dignity of "science" behind their plans in order to win public approval.

Granting, therefore, the need and opportunity for a science advisory service, there is required a form of organization that can function effectively and a personnel that is informed, alert, judicial, courageous and wise. In the last analysis "by their fruits ye shall know them"; in other words, the strength and value of any science advisory body will grow or die in accordance with its ability to render valuable service, whatever may be its authority, composition or procedure. Recent events have given scientists an unprecedented opportunity to participate in the solution of important problems of policy, administration and personnel, by advising responsible officers of the government. On the degree of their ability cooperatively to handle this opportunity will largely depend its continuance and extension.

All through history from the time that Archimedes was called on to aid, by his scientific inventions, in the defense of Syracuse, scientific men have been called to work for their governments and to advise them on matters within their fields of expert knowledge. Experience has indicated that there is no group more eager to place their knowledge and services at the disposal of the government, even at considerable personal sacrifice. Experience has also shown that these advisory services to government may be of great value if properly organized and treated with understanding and respect by those in political power.

An outstanding example of successful scientific advisory service to government is found in the present organization of advisory councils to the British Government. The first of these councils to be organized, and the one having the most extensive responsibilities, is the Advisory Council to the Department of Scientific and Industrial Research. The ten members of this council are chosen for their scientific and industrial qualifications and are appointed for terms of five years by the lord president of the Privy Council after consultation with the president of the Royal Society. The annual parliamentary grant for governmental scientific and industrial research is expended in a manner recommended by this advisory council, and the Department of Scientific and Industrial Research is in fact the administrative agency for carrying out the recommendations of the advisory council when approved by the lord president. The members of this council attend meetings on official business on about twenty days in each year and receive an honorarium of 150 pounds

per annum in lieu of reimbursement for personal expenses. In addition to the responsibility for governmental research agencies, this advisory council also submits recommendations for governmental grants to universities for research projects and research fellowships and also to industrial associations on a joint contributory basis for scientific research of general benefit to these industries.

There is an analogous Medical Research Council and an Agricultural Research Council, both organized under the Privy Council and with similar responsibilities in their special fields. The finest scientific and industrial talent of the country is freely drawn upon by the government in the appointments of these advisory groups. It takes only a superficial study of the operations of these councils and their numerous subcommittees to become quickly convinced of the effective manner in which this sister English-speaking nation has created a plan of cooperation between the technical talent of the country and the government, which is leading to splendid results for the economic and social welfare of the country.

There are similar tendencies in the other European nations. In Norway, for example, no appropriations are made to certain scientific services of the government without examination and approval by a distinguished civilian advisory committee, and the government now has under way a study of means of improving and extending this advisory service. In Italy the National Research Council is assisting the government to bring about more comprehensive programs of research by Italian industrial organizations. In Russia the Academy of Sciences of Moscow has been called upon to aid the government in organizing the great system of research institutes recently created throughout the country and now in process of doing some of the finest and most progressive scientific work to be found anywhere in the world.

In the United States three notable steps have been taken by the Federal Government to provide for itself disinterested and competent advice upon scientific matters:

(1) The National Academy of Sciences was established by an act of Congress and approved by President Lincoln on March 3, 1863, with the specification that "the Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments and reports to be paid from appropriations which may be made for the purpose," subject to the condition that "the Academy shall receive no compensation whatever for any service to the Government of the United States." Throughout its history the academy has rendered valuable service, principally in advising the government in regard to the organization of some of the federal scientific bureaus. In comparison, however, with the magnitude of scientific activity in the government and continued importance of problems involving organization, programs, personnel and budgets, I think that it may fairly be said that this arrangement has fallen far short of meeting the needs and opportunities for scientific advisory service. For example, the academy has been called upon by governmental agencies only about 100 times in the last seventy-two years, and of the eleven subjects thus referred to the academy directly by the Congress, only three related directly to the program or administration of the federal scientific services. These involved the National Board of Health (1870), the Coast and Geodetic Survey (1884), and a general report on the scientific work of the scientific services (1909). The other requests concerned scientific ques-

tions such as the introduction of the metric system, vivisection, the adoption of centigrade and Fahrenheit temperature scales and other matters of like nature.

The reason for this relative inactivity of the academy in the field in which it was created to perform can not, in my judgment, be ascribed to dearth, in the academy membership, of men eminently qualified to advise the government on its scientific problems, for there is no question but that its membership has contained men of outstanding distinction and accomplishments in all fields of science. There may be a minor element of weakness in the very fact that absence of active duty in advising the government has resulted in relatively little attention by the academy to peculiar qualifications for such service in considering nominees for election.

I believe that the major weakness in the present organization of the National Academy of Sciences, as an agency for advising the government upon scientific matters, lies in the phrase "whenever called upon by any department of the Government." There is no provision in the government, as there is in the British Government, whereby the scientific advisory services are automatically called upon when important scientific problems arise. The result is that few of the high administrative officers in the government, as they change from one administration to another, realize or take advantage of the opportunities for disinterested and competent assistance from the academy in handling the problems continually arising in the administration of the scientific bureaus under their jurisdiction. As a consequence this type of service has not been actively in the minds of the members of the academy, of whom the majority have rarely, if ever, been called upon to exercise this advisory function.

While, therefore, the National Academy of Sciences has had a distinguished history and has performed some very useful functions for the advancement of science, it has not handled the needs and opportunities for scientific advice to the government in an adequate manner. This failure is no reflection on the academy but has been, I believe, inherent in its organization and is also due in part to the type of public servant who is usually elected to high office in our government. For the most part these men have a legal training and a political and opportunistic outlook. They may be able and well-intentioned, but they, too, rarely have a sufficient scientific background or philosophic outlook to give them a sympathy and understanding of the nature, purposes and values of scientific work.

(2) The National Research Council was organized by the National Academy of Sciences in 1916 at the request of President Wilson as a measure of national preparedness in the face of the serious international situation at that time. At the President's further request, it was perpetuated by the National Academy of Sciences on April 29, 1919. As stated in its articles of organization, the purpose of the National Research Council is "to promote research in the mathematical, physical, and biological sciences and in the application of these sciences to engineering, agriculture, medicine, and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare, as expressed in the Executive Order of May 11, 1918." This executive order stated the objectives of the National Research Council to be "to stimulate research . . . , to survey the larger possibilities of science, to formulate comprehensive projects of research, and to develop effective means of utilizing the scientific and technical resources of the country for dealing with these projects, to promote cooperation in research at home and abroad . . . , to serve as a means of bringing American and foreign investigators into active co-

operation with the scientific and technical services of the War and Navy Departments and with those of the civil branches of the Government, to direct the attention of scientific and technical investigators to the present importance of military and industrial problems in connection with the war . . . , and to gather and collate scientific and technical information."

The National Research Council is, in a sense, an operating arm of the National Academy of Sciences and is permanently organized into divisions with representatives from all major scientific bodies. These divisions are served by numerous permanent and temporary committees, whose membership in each subject represents a cross-section of American leadership in the respective fields within and without government circles. There is thus provided an extensive framework for mobilizing the scientific forces of the country, which functioned with great effectiveness during the war and which is permanently available, even if not always active, as an important element of national preparedness.

The National Research Council is admirably set up to assist the government in one aspect of science advisory service; namely, in the organization and supervision of cooperative investigations aimed at specific scientific or technical objectives of interest to the scientific bureaus. For such purposes, the National Research Council is continually active, though, like other organizations, this activity is limited through limitation of funds for operating expenses. In its present organization, however, the National Research Council is not well organized for rendering effective advisory service to the government in matters of policy or organization. Its essentially representative character is admirable from the point of view of coordinating scientific agencies, but is not well adapted to the selection of the best personnel for advisory service on matters of policy. Furthermore, an inherent element of strength of the National Research Council is the inclusion of representatives of the governmental scientific services, but for obvious reasons, any organization which is created to give disinterested advice to the government on matters of policies, programs and administration of its scientific bureaus, can not contain in its membership representatives of these bureaus. For these reasons, therefore, the National Research Council is not well adapted to act as scientific adviser to the government.

(3) The Science Advisory Board was appointed by Executive Order of President Roosevelt on July 31, 1933, "in order to carry out to the fullest extent the intent of the above Executive Order (that of President Wilson creating the National Research Council)—with authority, acting through the machinery and under the jurisdiction of the National Academy of Sciences and the National Research Council, to appoint committees to deal with specific problems in the various departments." This board was created for a limited period, which expired on December 1, 1935, and was composed of the following scientists and engineers:

Karl T. Compton, *chairman*, president of the Massachusetts Institute of Technology, Cambridge, Massachusetts.

Roger Adams, professor of organic chemistry and chairman of the department of chemistry, University of Illinois, Urbana, Illinois (president-elect of the American Chemical Society).

Isaiah Bowman, chairman, National Research Council; Director, American Geographical Society, New York City (now president of the Johns Hopkins University).

W. W. Campbell, president, National Academy of Sciences, Washington, D. C.

Gano Dunn, president, J. G. White Engineering Corporation, New York City.

Simon Flexner, formerly director of the laboratories of the Rockefeller Institute for Medical Research, New York City.

Frank B. Jewett, vice-president, American Telephone and Telegraph Company; president, Bell Telephone Laboratories, Incorporated, New York City.

Lewis R. Jones, professor of plant pathology, University of Wisconsin, Madison, Wisconsin.
Charles F. Kettering, vice-president, General Motors Corporation; president, General Motors Research Corporation, Detroit, Michigan.
C. K. Leith, professor of geology, University of Wisconsin, Madison, Wisconsin.
Frank R. Lillie, Andrew MacLeish distinguished service professor of zoology and embryology and dean of the biological sciences, University of Chicago, Illinois.
John C. Merriam, president, Carnegie Institution of Washington, Washington, D. C.
R. A. Millikan, director, Norman Bridge Laboratory of Physics, and chairman of the executive council, California Institute of Technology, Pasadena, California.
Milton J. Rosenau, Charles Wilder professor of preventive medicine and hygiene, Harvard Medical School, and professor of epidemiology, Harvard School of Public Health, Boston, Massachusetts.
Thomas Parran, state commissioner of health of New York, Albany, N. Y.

The most active work of this board has been done through its nineteen special committees with an aggregate personnel of 101 scientists, engineers and industrialists, who, in each case, were selected for their peculiar fitness for the problem in question. It is significant proof of the willingness of the highest type of technical talent of the country to serve the government on important matters that not a single individual who was asked to serve on one of these committees refused the assignment. In some cases this work involved several months of almost continuous duty and in all cases was done without remuneration except for reimbursement of personal expenses incurred. These committees were usually under the chairmanship of a member of the board and were given the greatest freedom of initiative, and absence of red tape, actively to pursue their objectives. The effectiveness of their work is due jointly to their able personnel and to the freedom and responsibility which was given them.

The board as a whole met at intervals of two or three months to plan the organization of new projects, to receive and discuss the reports of its committees and to take action on matters of policy. While the committees were given great freedom in carrying out their studies and formulating their recommendations, the board itself exercised control of the manner in which these recommendations were submitted to the appropriate government officials and carried on the subsequent work of conference with these officials for the purpose of putting the recommendations, as far as possible, into effect.

The scope of activities of the Science Advisory Board is best illustrated by the names of the committees. These committees were set up to handle specific assignments, but most of them handled a succession of problems submitted to the board from the responsible government officers, who included department secretaries, the director of the budget, the federal coordinator of transportation and the President himself.

Executive Committee.
Committee on the Weather Bureau
Committee on the Geological Survey and Bureau of Mines
Committee on Economic Resources of the Boulder Dam Region
Committee on the War and Navy Departments
Committee on the Policy of the Government in relation to scientific research
Committee on Land Use
Committee on the relation between fundamental sciences and the scientific study of human problems
Committee on Railway Research
Committee on the Bureau of Standards
Committee on Surveying and Mapping Services of the Federal Government
Committee on Research in the Land-Grant Colleges
Committee on the Bureau of Chemistry and Soils
Committee on Soil Surveying and Soil Research
Committee on Medicine and Public Health
New Industries Patent Committee
Committee on the Design and Construction of Airships
Committee on Signalling for Safety at Sea
Committee on Biological Abstracts

In addition to the work suggested by these committees, there were some activities of a confidential nature, not publicly reported, and there were others which were carried through by the board as a

whole, notably the recommendation to the President of "A National Program for Putting Science to Work for the National Welfare."

Although the executive order of the President assigned to the Science Advisory Board a task which proved to be of considerable magnitude, no provision was made for financing the operations of the board. The necessary expenses of operation included secretarial help and office supplies, reimbursement of travel and other out-of-pocket expenses of the board and its committees, and occasionally the employment of an expert to gather and collate necessary information. The appointment of the board would therefore have been largely futile had not the Public Administration Clearing House made an initial grant to support the work of the board in its first month or two, and had not the Rockefeller Foundation then stepped into the breach and made an appropriation to the board of $50,000, which was just sufficient to cover its operating expenses for the balance of its term of appointment.

It would be impossible in this brief article to go into the details of the activities of the Science Advisory Board. A full description of these activities may be found in the two official reports of the Science Advisory Board, published in September, 1934, and November, 1935. A limited number of copies of these reports is available on application to the National Research Council, 2101 Constitution Avenue, Washington, D. C. It may be interesting, however, to summarize very briefly the extent to which the work of the board has led to positive results.

In several instances the board was requested by department secretaries to nominate candidates for appointment to the highest administrative posts in scientific bureaus. In every case the appointments were made in accordance with the nominations submitted by the board.

In a goodly number of cases the recommendations by the board have been put completely into effect. These cases include the consolidation and strengthening of the Mineral Statistics Services, the institution of scientific methods for determining the efficacy of measures to combat soil erosion, increased appropriations for scientific research in the public health service, the appointment by the President of a planning committee on mineral policy, the introduction of new features of program and interdepartmental coordination in the work of the United State Weather Bureau, and the introduction of a cost accounting system with a new form of organization for appropriation purposes in the activities of the National Bureau of Standards.

In the majority of cases the recommendations of the board have been partially put into effect as fast as appropriations, personnel or ability to secure necessary authorization or cooperation have permitted. In this category satisfactory progress is being made in the organization of a cooperative research agency by the Association of American Railroads, in the application of new methods of forecasting by the Weather Bureau, in a realignment of some aspects in the programs of the Geological Survey, Bureau of Mines and Bureau of Standards, and in the modification of practices in the Patent Office and in the handling of patent cases in the courts.

In some cases the board's report was purely factual, as in the study of the economic resources of the Boulder Dam region and in the compilation of information and programs for the use of federal agencies engaged in studies of soil erosion and land use.

In the report on mapping services of the Federal Government, there was recommended a consolidation of those bureaus whose sole activity is the production of maps to form a single efficient mapping bureau. It was shown that

decided economies could thereby be secured and that the enormous economic interest of the country in the completion of its mapping program could be greatly facilitated. Unfortunately, lack of authorization to effect these consolidations has blocked the favorable action which for a time appeared probable, and it is greatly to be hoped that this subject will receive due consideration in the next session of Congress.

On the whole the board feels that the positive results of its work have been as great as could reasonably have been expected and it offers tribute to the sincere desire of government officials to conduct the affairs of the scientific bureaus for which they are responsible in such manner as to give the best possible service to the country. The friendly cooperation of department secretaries and bureau officials throughout has been most noteworthy.

Conclusion

Whatever may have been the successes and failures in the efforts of the National Academy of Sciences, the National Research Council and the Science Advisory Board to render effective advisory service to the Federal Government, there is no doubt that the most important consideration is of the future rather than the past. The ideal program would be the planning of a science advisory service based upon the lessons from all past experience. Realizing this fact, the President has opened the way for such a constructive step through the following letter addressed to the president of the National Academy of Sciences.

THE WHITE HOUSE

Washington

July 15, 1935

Dr. Frank R. Lillie,
President, National Academy of Sciences,
Constitution Avenue and 21st Street, N.W.,
Washington, D. C.

My dear President Lillie:

In accordance with recommendations from you and from Doctor Karl T. Compton of the Science Advisory Board, I am signing an Executive Order extending the Science Advisory Board to December 1, 1935, in order that the work now under way can be carried on until more permanent arrangements are made by the National Academy of Sciences.

The National Academy of Sciences under the provisions of its Congressional charter is required "whenever called upon by any department of the Government to investigate, examine, experiment and report upon any subject of science or art." It has, through its National Research Council, permanently organized contacts with the scientific and technical bodies of the country. During the past two years it has been implemented by the Science Advisory Board, through which its members have become more intensively acquainted with the scientific services of the Government and their problems.

In order to secure the most effective scientific advisory service, based on the experience of these three agencies, I hereby request the Academy to provide some single agency, board or committee which can carry on the work of the Science Advisory Board and related activities after December 1, 1935.

Upon receipt of word from the Academy as to the committee or other organization through which the Academy wishes to perform this service, I shall be glad to request the Government departments and scientific bureaus to utilize and cooperate with that agency.

Sincerely yours,

S/ FRANKLIN D. ROOSEVELT.

Just what form this revised science advisory service will take as to its organization and methods is now in process of development. Certain aspects of the situation must receive consideration. It is important that duplication of science advisory services be eliminated as far as possible and that the existing ones be closely coordinated.

For this reason a science advisory service should certainly be set up under the Congressional authority vested in the National Academy of Sciences but in such manner as to avoid any conditions which may hitherto have prevented the academy from its best possible performance in this field. It is also important that the science advisory service operate in sympathetic coordination with the National Resources Committee, which has been given broad powers to coordinate and mobilize the resources of the country, both physical and intellectual.

The Science Advisory Board, in March, 1935, submitted to the President a recommendation embodying its best judgment at that time in regard to the organization of a permanent science advisory service. Certain situations which have subsequently intervened make it probable that some details of this recommendation will have to be modified, but the basic features of the plan there outlined would seem to embody the best past experience of the United States and Great Britain as applicable to the situation under our own government.

This plan envisages the appointment of a central science advisory board or committee of completely non-political character, selected by the National Academy of Sciences. Such a board would have certain authority under the Congressional charter of the academy. In addition to this, it is believed to be essential that the board should have specific recognition and authorization by the President of the United States and his administration in order that it may readily be recognized and used by his official family of the department secretaries, since experience has shown that it is through these secretaries that requests for advice in scientific programs or policies are most frequently received. It is furthermore specifically recommended that the director of the budget be requested by the President to secure the advice of this board in regard to the budgets and appropriations of the scientific bureaus. While doubt has been expressed in some quarters as to whether such an arrangement would be entirely acceptable to all parties concerned, this plan has operated effectively in Great Britain and has precedent in our own country in the work of the Fine Arts Commission. It has furthermore been warmly approved by a number of prominent men who hold, or have held, official positions in the government departments which are involved.

In order to enable such a central science advisory board to deal effectively with problems of the various departments, it is further recommended that permanent subcommittees of the central board be established in connection with the more important scientific bureaus of the government. Ever since the establishment of the National Bureau of Standards, there has been a visiting committee of this type, which has operated with considerable influence in consultations with the Secretary of Commerce, the director of the bureau and the director of the budget. More recently at the recommendation of the Science Advisory Board, a similar advisory subcommittee has been set up to serve the United States Weather Bureau. There are advisory committees also attached to the United States Public Health Service and the Geological Survey. The present proposal would coordinate these advisory groups through the central science advisory board and would bring to the aid of the Federal Government the best scientific and technical talent of the country in a coordinated advisory service on scientific matters. Such a comprehensive service would be of inestimable value to the future welfare of the country and it is greatly to be hoped that some form of organization along these general lines may be consummated and may receive from the government the necessary authorization and financial support for its effective functioning.

ON THE STRUCTURE OF SOLID BODIES

By Dr. EUGEN WIGNER

PROFESSOR OF MATHEMATICAL PHYSICS AT PRINCETON UNIVERSITY, 1930–35

BUDAPEST, HUNGARY

(1) PHYSICS always develops in two directions. One front pushes forward towards phenomena which do not yet fit into the general picture, and the victories on this front are marked by important changes in our fundamental concepts. On this front to-day the main struggle is for a better understanding of nuclear phenomena by the application of both theory and experimentation. But, apart from this search for new concepts, there is a constant effort directed toward the deepening and broadening of our knowledge of phenomena which, we believe, *can* be understood on the basis of existing concepts and theories. Doubtless this second front is of less importance. It rarely leads to fundamental discoveries in physics proper but supports rather the studies on the borderline of this science, such as physical chemistry and the applied sciences. Spectroscopy suddenly changed, about six years ago, from the first to the second category, and not much later it became apparent that the study of the solid body belongs also to this second class. In spite of this, it remains one of the most attractive of all fields, since it deals in a scientific way with those subjects with which we must deal in our everyday experience. For example, we are never afraid when dropping a key that it will fly to pieces, as glass would, nor do we fear that a gold coin will dissolve in water nor evaporate if left for awhile in the open air.

X-ray studies have revealed that most of the solid bodies in our surroundings are crystalline. This does not necessarily mean that they are formed by one single crystal—although even this is true for bodies of such enormous size as icebergs. More commonly, they are polycrystalline, like the metal parts of ordinary tools, *i.e.*, a conglomerate of microscopic crystals of various sizes. Crystalline in this connection does not mean a regularly shaped body of the kind we see in our crystallographic collections, but only that the grains have a regular *inner structure* arising from the arrangement of the atoms in surprisingly regular *lattices*. Samples of such lattices are shown in Fig. 1. (The circles represent the centers of atoms; the lines have no physical significance and are drawn only in order to facilitate space-vision.) The region over which the regular arrangement has a certain orientation is called a microcrystal and may have a size anywhere from .00001 mm to 1 mm or even more. These microcrystals, generally possessing irregular boundaries, are heaped together in an apparently random manner to form the polycrystalline body. (Very little is known about how the microcrystals with their different orientations fit and stick together. Some assume a separate very thin noncrystalline phase which "pastes" them together, but there is no definitive evidence for this.)

The crystalline and polycrystalline substances constitute by far the greater part of all solid bodies found in nature. Practically all rocks are conglomerates of crystals, ice is crystalline, and so are all metals. The grains of sand are minute crystals and loam also is crystalline. Apart from the glasses and substances of organic origin, like wood, there are very few non-crystalline solids.

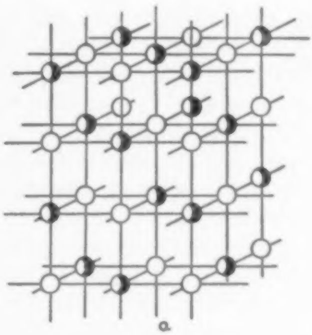
(2) A distinction not necessary in the case of gases or liquids must be made between different kinds of properties of solids.

Evidently, the consideration of a regular lattice is much simpler than that of an irregularly spaced heap of atoms. It is important, therefore, that many of the properties of a polycrystal are the same as those possessed by a perfect single crystal. These properties are connected with phenomena which affect the bulk of the material, like vaporization, fusion, specific gravity and compressibility. Our understanding of these "insensitive properties" is naturally the farthest advanced, and we shall devote most of our attention to them.

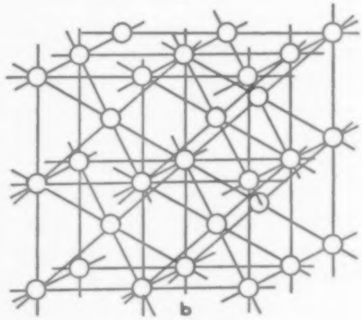
Unfortunately, a great many very important properties belong in a second "sensitive" class. The breaking strength, for instance, is determined by the very weakest part of the crystal; one single imperfection of certain types may suffice to cause rupture under a very low stress, a tenth or even a hundredth of that which a perfect crystal could support. Fig. 2 gives a rough picture of how this can happen: the stress, characterized by the stress lines, concentrates in the neighborhood of the imperfection and attains values which are many times those in the bulk of the material. This highly concentrated stress can widen the notch and finally break the whole body. Thus, the parts of a solid which lie above and below a crack not only do not increase the strength of the material but very definitely weaken it. One can say that the strength of a solid is much smaller than that of its weakest part.

The situation for the electric breakdown of insulators parallels that for the elastic limit (the smallest stress which causes a permanent deformation), and the study of these sensitive properties of crystals involves besides a knowledge of the crystal in bulk, its criminology, *i.e.*, a knowledge of the most usual faults and imperfections.

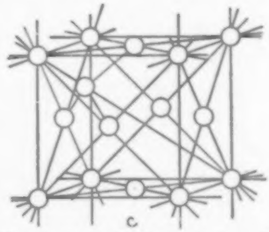
In addition to these extremes, there are, of course, a number of borderline properties. These are partly connected



a



b



c

FIG. 1a. PART OF A KCl LATTICE. THE SHADOWED SPHERES DENOTE THE POSITIONS OF THE K IONS, THE EMPTY ONES THE POSITIONS OF THE Cl IONS. THE DISTANCE BETWEEN NEAREST NEIGHBORS IS .00000031 mm. ORDINARY ROCKSALT HAS THE SAME LATTICE WITH SOMEWHAT SMALLER DIMENSIONS.

FIG. 1b. PART OF THE LATTICE OF AN ALKALI METAL. THE SPHERES REPRESENT THE CENTERS OF MASS OF THE ATOMS. THE DISTANCE BETWEEN NEAREST NEIGHBORS IS .000000372 mm IN SODIUM.

FIG. 1c. UNIT CELL OF THE DIAMOND LATTICE. THE DISTANCE BETWEEN NEXT NEIGHBORS IS .000000154 mm. Si HAS A SIMILAR LATTICE WITH A DISTANCE OF .000000234 mm BETWEEN NEAREST NEIGHBORS.

with the external surface, as, for example, the thermionic emission of electrons, or with the internal boundaries of crystallites, exemplified by the electric conductivity of compressed salts. All these properties are influenced to some extent by small contaminations. With extreme care and sufficient experimental skill reproducible results are sometimes obtainable for these phenomena, and they are then frequently as amenable to theoretical interpretation as the insensitive properties.

(3) Let us return now to the insensitive properties. Even with regard to these, the variety found in solids is much greater than that in gases. From the empirical point of view, four main classes, with many transitions between them, can be distinguished. This classification, which in its essentials goes back to Grimm, contains:

(*a*) *Molecular lattices.* Inert gases or saturated compounds like He, Ne, A, etc., H_2, N_2, O_2, etc., CH_4, C_2H_6, H_2O, H_2S, etc., and all organic compounds form such crystals. They all have low heats of vaporization and condense only at comparatively low temperatures. They are soft and moderately brittle, are good insulators and are transparent, except in spectral regions in which the building molecules themselves show absorption.

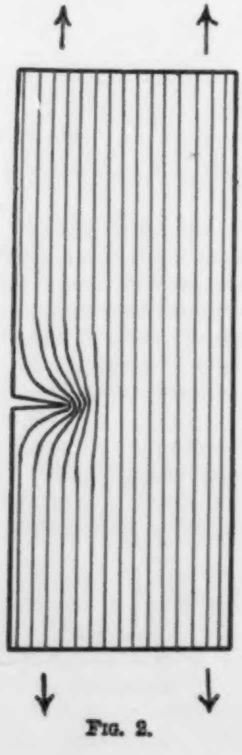


FIG. 2.

(*b*) Metals have in many respects properties opposite to those of class *a*. The binding forces between the atoms are much higher and the heat of vaporization greater, and they have an increased hardness. Their most remarkable property is, of course, that they are good conductors for electricity and heat. They are opaque and owe many of their important applications in industry to their plasticity; that is to say, they break only after great deformations.[1] Their solubility in each other is considerable (alloys), but they never dissolve in solids of other classes.

(*c*) *Valence lattices* (diamond, quartz, carborundum) and

(*d*) *Ionic lattices* (salts) are rather similar types. They both have high heats of vaporization, strong cohesive forces, are transparent like molecular lattices, are good insulators and are hard and brittle. The main difference between them is that while the former are formed from neutral atoms, the building stones of the salts are electrically charged ions, held together by the electrical attraction between opposite charges. They dissolve, therefore, in liquids with high dielectric constants like water, which diminish the electrical attraction of the ions down to a small fraction of its original value.

[1] This is why they do not break if dropped. The sudden stopping on the ground causes great stresses. In consequence of this, the metal will suffer a plastic deformation which will not cause rupture, however. In consequence of the plastic deformation the metal will act as its own shock absorber by allowing more time for the stopping of the bulk of the material.

This characterization of the four groups of solids should be understood in the same sense as should a similar characterization of a class of plants in botany. It does not give ironclad rules, but rather ideals from which the real cases often deviate; especially is this true for the more complicated compounds. Also various kinds of transitions occur between the four groups. Sometimes inside individual layers we have a lattice of one kind, while the forces *between* the layers are characteristic of another of our classes. There are also cases which are really transitional in all their behavior between two (or even three) groups, especially between valence and ionic lattices.

These exceptions are rare, however. The importance of the four groups becomes most evident, perhaps, if we realize that instinctively we classify into one of these groups all solid bodies of inorganic origin, which happen to fall into our hands. The above characterization of the four groups is the scientific description of what all of us would expect with regard to vaporization, hardness, electric conductivity and brittleness after some inspection and handling of such substances as condensed CO_2, rhodium, carborundum and Glauber's salts, even if we had never seen them before. On the other hand, we wouldn't quite know what to expect from transition lattices such as carbide or even graphite.

(4) The enormous differences between the physical properties of different kinds of lattices make it evident that the forces holding the atoms or molecules together are very different in the four cases. In order to understand the origin and nature of these forces, we must first recall the structure of isolated atoms and molecules. This is probably well known to the readers of the SCIENTIFIC MONTHLY. It is only recently that Professor Eyring gave an excellent review of this subject in these pages.[2] According to Rutherford, the atom contains, first of all, a heavy nucleus, containing all the positive charge and (except for about one part in two thousand) all the mass of the atom. The center of gravity of the atom practically coincides with the nucleus, so that in Fig. 1 the circles may be regarded alternatively as the positions of atoms or nuclei. This nucleus, though small, is full of mysteries, which fortunately are of no importance in understanding the solid state. The negative charges, which exactly compensate the positive charge of the nucleus of a neutral atom, are carried by light particles, the electrons. These electrons surround the nucleus like an enormous cloud with dimensions a hundred thousand times that of the nucleus, although the cloud is itself only about .0000001 mm thick. Quantum mechanics, created by Heisenberg, Schrodinger and Dirac, unravelled for us about eight years ago the exact laws of motion of this electron cloud. It is now possible to calculate the density of this cloud at different distances from the nucleus, and from this one would naturally expect to obtain important information concerning the structure of solids, by comparing the density distribution of the electrons for different distances in the lattice. The outermost or valence electrons are responsible for the entire chemical behavior of the atoms. In Fig. 3, the full line represents the density of the valence electrons as a function of the distance from the nucleus. In addition to this, the position of the nearest neighbor is marked on the abscissa and the density distribution of the valence electron of this neighbor is plotted *in the direction of the first atom* as the dotted line. The first plot is for He, the most characteristic representative of a molecular lattice; the second is for sodium, a typical metal; the third for

[2] SCIENTIFIC MONTHLY, 39: 415–419, November, 1934.

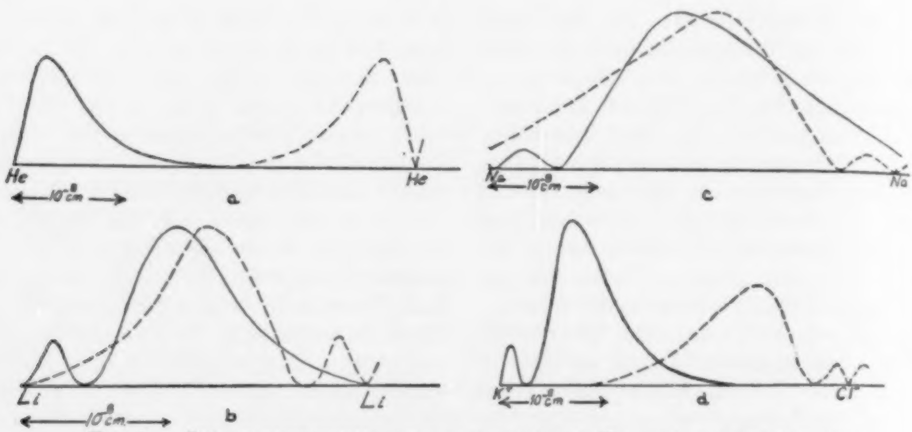


FIG. 3a. CHARGE DISTRIBUTION OF TWO NEIGHBORING He ATOMS IN THE LATTICE.

FIG. 3b. CHARGE DISTRIBUTION OF EXTERNAL ELECTRONS IN FREE Si ATOM (FULL LINE). THE DOTTED LINE IS THE CHARGE DISTRIBUTION OF THE VALENCE ELECTRONS OF ANOTHER Si ATOM, PLACED AT THE SAME DISTANCE FROM THE FIRST AS IN THE LATTICE.

FIG. 3c. CHARGE DISTRIBUTION OF THE VALENCE ELECTRON IN FREE SODIUM ATOM (FULL LINE). THE DOTTED LINE IS THE CHARGE DISTRIBUTION OF THE VALENCE ELECTRON OF ANOTHER SODIUM ATOM, PLACED AT THE SAME DISTANCE FROM THE FIRST AS THE NEAREST NEIGHBOR IN THE LATTICE.

FIG. 3d. CHARGE DISTRIBUTION OF EXTERNAL ELECTRONS IN K ION (FULL LINE) AND Cl ION (DOTTED LINE). THE DISTANCE OF THE ZEROS OF THE TWO PLOTS IS EQUAL TO THE DISTANCE OF THE NEAREST IONS IN THE KCl LATTICE.

the valence lattice of silicon and the last one is for KCl, which closely resembles ordinary rocksalt.

We realize at once an important difference between the molecular and ionic lattices (first and last pictures) on the one hand, and the metallic and valence lattices on the other. For the former, the overlapping of the electron clouds is small, in the latter ones it is so great that it is impossible to tell to which atom a certain valence electron belongs. In the former cases the constituent atoms or ions, although attracted by their neighbors, have their charge distribution but slightly affected. This is not so for the metals and valence lattices. There is no region between the atoms with a small charge density and consequently no forbidden region for the electrons. The electrons are able to pass from one atom to the next. Thus the valence electrons move freely and are common to the whole lattice. This is of decisive importance for the properties of these substances.

In molecular and ionic lattices, it is possible to consider the constituents as different entities. Born's classical theory of mechanical electric and thermal properties, which treats the atoms and ions of the lattice as individuals, attained its great successes for these lattices.

The great differences in the behavior

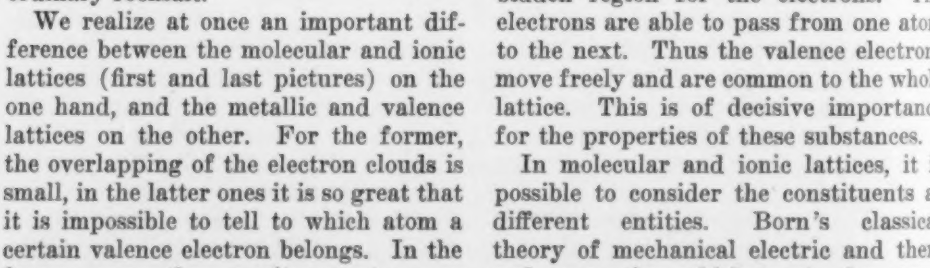


FIG. 4.

of the two classes are due to the different character of the constituents. These are neutral atoms in the first case, in the ionic lattices they are charged particles. The electric forces between ions are very strong, and this makes the cohesive forces, the heat of vaporization and hardness great. The distances between neighboring ions are given by the charge distribution, as illustrated in Fig. 3. The calculations of ionic radii were carried out by L. Pauling in California and show remarkable agreement with the values derived by Goldschmidt from observations. These lattices are always so constructed that the positive ions are surrounded by negative ions, the negative ions by positive ones. (*Cf.* the NaCl lattice in Fig. 1.) Since opposite charges attract each other, there are considerable forces holding these lattices together.

The nature of the forces in molecular lattices is not so simple. Van der Waals was the first to assume that condensation is caused by the same forces which are responsible for the deviation in the behavior of real gases from the ideal gas laws. This proved to be true in the case of molecular lattices, and the laws of these forces have been recognized by London and Wang on the basis of quantum mechanics and called van der Waals forces.

Of course, there is no attraction due to electric charges in molecular lattices, since the constituents are uncharged. And, indeed, the attraction can not be understood as long as we consider the electrons as charge clouds. But if we remember their corpuscular nature, we realize that they can form *dipoles* with the nucleus. The direction of this dipole will vary quickly because of the quick motion of the electrons. There will be no force, in the mean, on a dipole of constant orientation, since the attraction for one dipole orientation is as great as the repulsion for the opposite orientation—and all dipole directions are equally probable. But if two variable dipoles face each other, it will be possible that the two attractive configurations *a* and *c* of Fig. 4 will occur more often than the repulsive configurations *b* and *d*, although all the orientations for the *single* dipoles are equally probable. London and Wang have shown that this is actually the situation, and thus laid the foundation not only for a satisfactory theory of molecular lattices but also for a theory of the behavior of real gases.

Naturally, the van der Waals forces are much smaller than the Coulombic forces between ions. Thus, the cohesion in molecular lattices is small, the vaporization easily giving volatile substances. Also it is evident that these very small forces will be important only if no other stronger forces are present. Molecular lattices will be formed by saturated compounds and inert gases.

(5) Fig. 3 shows us that the metallic and valence lattices form the more compact modification of matter, as contrasted with molecular lattices and salts. This gives important information concerning the question of the behavior of solids under extremely high pressures: according to Bernal, who first emphasized this point, they will go over into metals or valence lattices. A convincing piece of evidence for this point of view, which is quite independent of calculations of charge distribution, is furnished by the phenomenon of *allotropy*. This is the name given the phenomenon of the appearance of the same chemical element in different "modifications" with widely different physical and chemical properties. The ordinary, yellow (white) form of phosphorus forms a somewhat complicated molecular lattice. It is a good insulator, soft, dissolves in organic solvents and has a density of 1.83. Bridgman at Harvard subjected this element to very high pressures, and the lattice "collapsed." It transformed into *black*

phosphorus, which has a density of 2.70, is a fairly good conductor of electricity and insoluble in organic liquids. And this is the general rule: Whenever an element has two allotropic modifications, the *metallic or valence form has the higher density.* The following table illustrates this point:

As, metallic	5.72	yellow	2.03
diamond	3.51	graphite	2.24
black phosph.	2.70	yellow	1.83
Se, metallic	4.82	red	4.47
Sn, white	7.28	grey	5.76

Calculations made in our laboratory by H. B. Huntington show that metallic hydrogen should also exist, though only under extremely high pressures, and that it should have a density many times higher than that of the usual molecular form.

I shall not go into detail with regard to the next question which naturally arises—the cause of the fundamental difference between valence and metallic lattices. Although both form in the compact modification of matter, apart from the high heat of vaporization and boiling point, they have nothing in common. The reason for this is deeply rooted in the principles of quantum mechanics and has been brought out but lately by works of Peierls and Brillouin. According to their investigations, it is essential for a valence lattice that the number of valence electrons be *even*, and this rule holds without exceptions. We owe much valuable information concerning the structure and crystal form of valence lattices to Pauling and Slater, but a review of their work would greatly exceed the scope of this report.

I hope that I have succeeded in imparting to the reader the impression that the foundations for the understanding of the nature of the solid state are laid. Still, it will require much thorough work, perseverance and many new ideas before we will be able to add the theory of solids as a finished story to the building of physics and before we will be able to apply with success our knowledge in industry.

The progress in the explanation of the properties of solid bodies is due on the theoretical side to the newly developed quantum mechanics, and experimentally mainly to the study of crystal structure by x-rays. Without these tools we would face these problems as helplessly as we still face the problem of liquids where x-ray studies have proved less efficient so far.

IN QUEST OF GORILLAS

III. KIVU, LAND OF OLYMPIAN CLOUDS

By Dr. WILLIAM KING GREGORY

CURATOR OF COMPARATIVE ANATOMY AND OF ICHTHYOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY; PROFESSOR OF PALEONTOLOGY, COLUMBIA UNIVERSITY

WE got down in front of the hotel at Bukavu, which was to be our home for the next ten days, and were presently greeted by the genial hosts, Mr. and Mrs. Stephenson. It was indeed a pleasure to meet these sterling English people and their three little children and to live in their hotel. Mr. Stephenson, an ex-soldier, had taken part in the siege of Gallipoli and other scenes of the Great War, while Mrs. Stephenson had served as a war nurse. He owned a coffee plantation near by, while she was the manager of the hotel.

That afternoon I walked down the main street of Costermanville, along the high promontory that runs out into the lake. Wave-like mountains run along parallel to the lake on both sides of it and others cross the view on the north. I did not then realize that I was looking only at the very narrow tip of one horn of the lake, the main body of which lies far to the north. Almost the whole town, consisting chiefly of this one broad avenue, had the appearance of being brand-new. Many smart-looking new brick houses with bright-colored roofs were going up, the brush-like *Casuarina* trees on either side of the road had been planted not very long ago and everything was spick and span from the foot of the long hill to the bright-colored government buildings near the tip of the long fish-hook-like curve. All newly cut embankments and roads were of the bright red color that is so characteristic of tropical Africa.

Here at about 4,500 feet above sea-level the air was dry and fairly cool, the bright sunshine was not too intense and one could lightly climb the hills and absorb the inspiring vistas of this land of titanic earth waves. This town, I was told, had grown from practically nothing in the past three or four years, partly as a result of the opening of the automobile road from Lake Tanganyika. About the town there was nothing of the roughness or recklessness that is so often seen in towns of rapid growth. All was proceeding according to an orderly and well-thought-out plan. It is one of the advantages of the excellent system of government in the Belgian Congo, in which, so far as the evidence presented itself to me, a consistent and highly successful attempt is being made to build up a beautiful country for the benefit of all parties concerned and with due regard for the rights of all.

Then I walked in the opposite direction, up the long hill to the empty market-place at the top. On each side of the street there is a line of small shops, mostly owned by the numerous great Belgian corporations, *Sociétés Anonymes* with alphabetic names, that have similar shops distributed all over the vast territory of the Belgian Congo. Here the shops offered a convenient place for the natives to spend the money they had gained by selling their produce in the market at the head of the street.

The market-place was empty, but many large black and white vulturine crows were soaring and flying over it. In the center was set up a hexagonal basaltic column about three feet high, which I knew must have come from some

place near by. This gave me a clue to the geologic structure of the surrounding mountains, which I was anxious to verify by further observation.

Toward evening I reached the top of a high hill overlooking the promontory on which the town was built. Evidently this spot had been fortified before or during the great war; before this Bukavu was nothing more than a native village, but now it commanded the main road from the south to Lake Kivu. Apparently no guns of any great size had been mounted here, but the low mounds and ditches would have been suitable for sharpshooters and machine guns. It was now solitary and a fine place from which to view the gray wave-like mountains and the splendors of the sunset. As I came down in the dusk toward the native village the rhythmic sounds of melodious voices humming for the dancers and the tinkling of many box-pianos (lukimbe) came up through the still evening air.

The next morning I went for a stroll through the native village, which lies at the neck of the promontory, and then some distance along the shore of the lake west of the promontory. Where all is new and strange almost everything is worthy of note, but I will begin with the activities of the street-cleaning gang in front of one of the shops of the numerous *Sociétés Anonymes.* Five men were seated basking in the plaza, posed like black Buddhas; they were about equally spaced from one another, like bees building a honeycomb. Each man held a short round broom, much like the kind that witches are supposed to carry; with this he slowly swept half-circles in front of him, pushing the leaves and scraps to the circumference. Every little while all five men would hitch forward very gently, so that the growing front line of leaves and rubbish was almost imperceptibly pushed out toward the gutter. I did not wait to see the end of this very slow moving-picture, but probably when one widening segment was cleaned off in this way, the men were under the painful necessity of getting up and walking across the plaza to begin a new cycle of well-moderated labors. Anyhow the result was an immaculately smooth and clean-looking plaza and the operation well illustrates a principle which the social Hymenoptera discovered millions of years ago: namely, the successful integration of almost infinitesimal efforts into purposive results that are often of great magnitude.

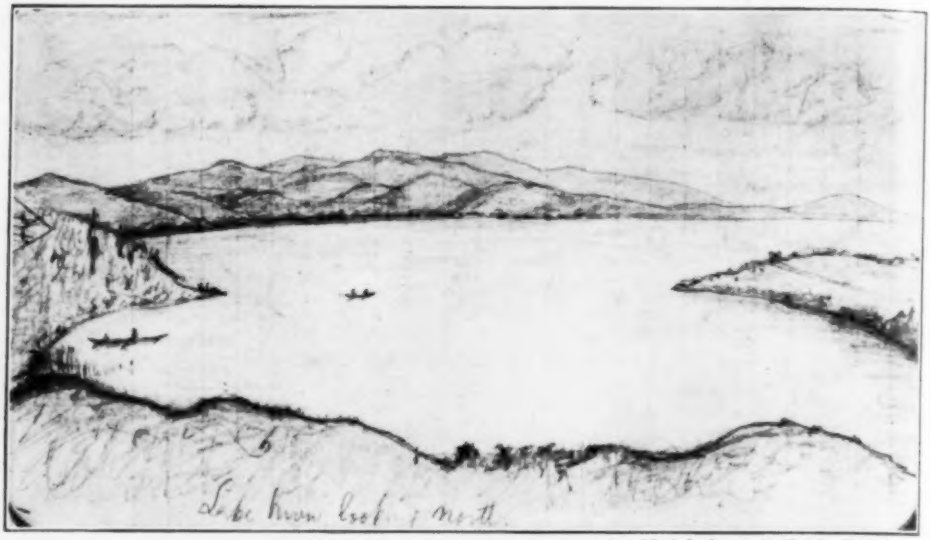
The incident also illustrates the African's gift for socializing labor, in the sense that labor becomes a social event, a training school in the fine arts of declamation and oratory. All this helps to disguise, at least in part, the fact that one lives under the curse of the descendants of Adam, who was condemned to earn his living by the sweat of his brow.

The visitor also gets the impression here and elsewhere that, as the arrangement works out, the blacks on the whole get far more benefit out of the foreigners than the reverse. For the foreigners keep the peace, and although the excitements and plunders of inter-tribal war are stopped, as well as the attractions of stealing women and making slaves, one is at least relieved of the constant strain and can bask peacefully in the sun; also the whites provide many jobs, especially on the roads; and one can move ever so deliberately with a moderate-sized basket of dirt on one's head and then get money to buy a swagger second-hand shirt or a real cast-off vest. Even the prisoners, who wear a brass collar around their necks and are thus tied together in long strings, do not look miserable or abused. They work on the roads not a bit harder than anybody else and jabber no less loudly and incessantly. One man with a gun is sufficient to guard a large number of prisoners, who seem quite resigned to their fate. Many a harassed man in America would find prison life in Africa a vacation.

The post-office near by offered another

—*Photograph by E. T. Engle*

WHAT THE WELL-DRESSED WOMAN WEARS AT BUKAVU



—*Sketch from Author's Note-book*

LAKE KIVU, LOOKING NORTH.

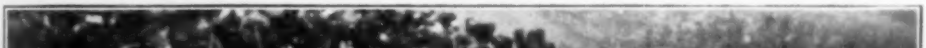
example of the African's pliant attitude toward life as it comes. There was a long line of natives with assorted old hats and other fragments of white man's clothing waiting to collect the mail for their masters. Although the line moved forward very slowly nobody betrayed the slightest trace of hurry or irritation, and that for several reasons. In the first place, it was their job to do just that, at the master's orders and at his expense. Secondly, even if it had been their own time they were spending, what of it? Thirdly, several of the near-by messengers in red fezzes, who were basking in the plaza, were tinkling the native box-pianos. Of course nobody was really stirred by this droning, in which they were suffused all the days and nights of their lives; but it afforded an agreeable tonal background for their *andante* reveries.

I, being a foreigner and therefore afflicted with the peace-destroying urge to be up and doing, must be getting on with my walk. So I turn down a long incline that leads to the populous native village at the foot of the hill. Some of the nabobs living in the houses along the terrace at the top of this hill do me the honor to interrupt the business of absorbing energy from the sun and to turn their eyes to inspect the "queer 'un." The frequent smiles which we exchanged indicated how amusing each looked to the other. But I always gazed with gravity and respect upon the thrice venerable old dames who were trudging up the hill with huge loads that they had carried for many miles.

So I go on down the long red hill to the bottom, where there is an enormous pit of red clay from which many blacks have taken out the material for bricks. Here is a gang of them in a great circular depression, mixing the clay with water by treading upon it in the manner of the biblical wine-treaders. I open up my camera and prepare to take a picture of the men in the pit. But I can not resist the temptation to show one or two of them who are near by the beautifully clear image in colors which is projected right side up on the ground glass at the bottom of the folding box. Oh, what ejaculations of surprise and approval:

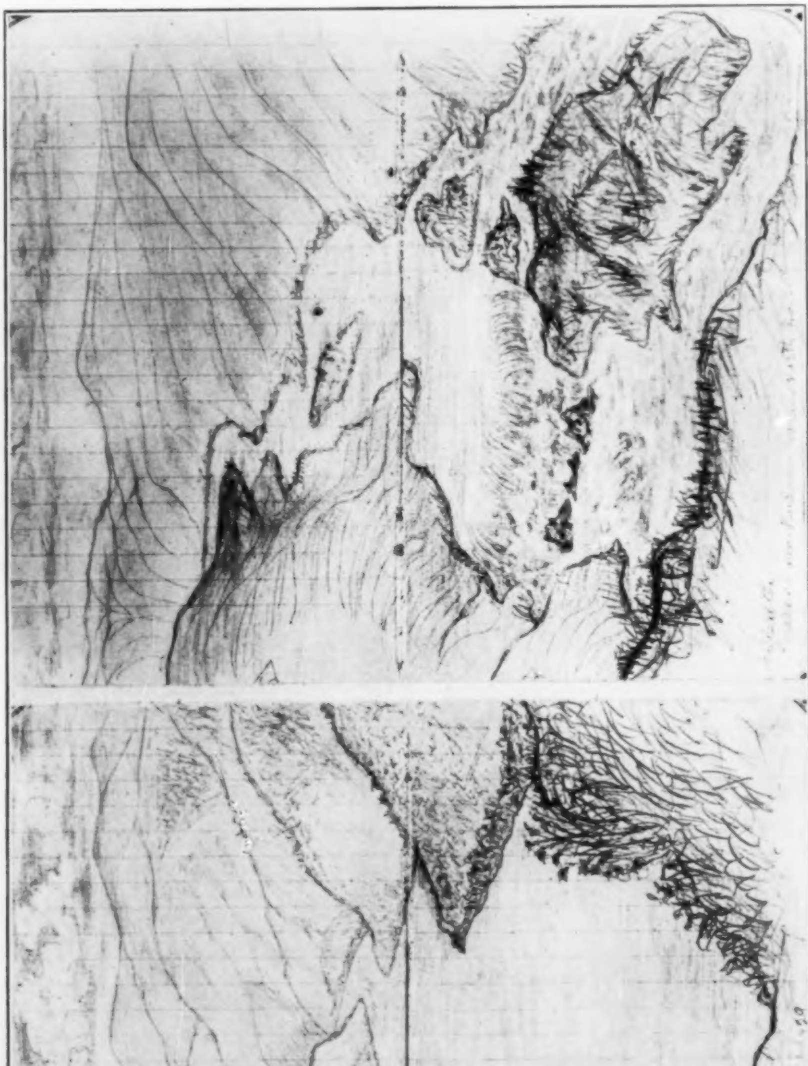
"E-e-e-e-e-e!" (*diminuendo*) "Ah! Keh!" (*staccato*), in the wheedling, crooning tones of a mother to her infant. But all this was too much for the curiosity of the men in the pit. Out they scramble, bearing quantities of red clay on their feet, and I am nearly mobbed in their bovine attempts to push closer and look in the wonder-box. Many get a look and soon all yield good-naturedly to my energetic gestures and gesticulations.

The next day (July 27) was market day (which occurs on every fifth day) and for the newcomer this is one of the great sights of Africa. From the villages that dot the nearly bare mountainsides a straggling army of blacks pours down the main path leading to "market hill." Women come trudging in with great basketsful of many kinds of produce on their backs; men, women, children and babies come to buy or sell and look on, and all together they send up a roar or hum that can be heard a long way off. But however interesting the people might be as individuals, there were too many of them crammed into one place, so after taking a casual look at the many groups crouching around their baskets, I went on up the path leading to the surrounding hills, going upstream against the procession of men with spears and women with burdens. Many of them saluted or gave me a cheery "Jambo, Bwana" as I passed. A few of the men were tall and thin, with rather narrow noses and less coarse features. They were rather haughty in mien and seldom saluted. They did not fail, however, to step aside to let the white man pass; nor did I care to interfere with the custom of the country, which unhesitatingly gives the priority to the white race on every occasion. This seems the only practicable rule, and I never noticed the slightest inclination to question its finality. These tall men very probably had in them the blood of northern invaders, the "cattle-keeping aristocracy" of East Africa. At the other extreme, some of the men had squat figures. In between



—*Photograph by H. C. Raven*

MARKET-DAY AT BUKAVU.



FALLS OF THE RUZIZI AT BUKAVU

GORGE OF THE RUZIZI, LOOKING SOUTHWEST

—*Sketches from Author's Note-book*

were the average run of medium-sized, flat-nosed blacks. More women were dumpy than otherwise.

Native clothing predominated among these up-country people and what little there was of it was worn with a dignity and grace that were in refreshing contrast to the ridiculous appearance of all those that by hook or crook could get hold of some cast-off garment of the whites. Greatly protruding abdomens and tumor-like umbilici were very frequent among the little boys; cases of terrible sores on the legs, although fairly common, were by no means as numerous as they were in many other parts of Africa. The skin was usually very dark, the lighter skin as well as mixed breeds being much rarer than in the lower Congo and West Africa. In general, really beautiful native articles seemed scarce and not very good. The native spears and knives were fair, but no decorated pottery, no beautiful baskets nor elaborately decorated gourds were noticed. One wonders how far this is due to replacement by articles of foreign manufacture.

As I walked along the mountain path I passed through several hamlets half hidden among the tall banana plants. Some of the older people were at home, basking in the sun in front of their round huts, while the boys played about or looked after the few long-horned cattle.

Making a wide detour around one of the hills I gained my first glimpse of this part of the Ruzizi River, where it breaks through the mountains south of the lake. Sitting down at a point high above the river and looking downward and outward, I tried to sketch in my notebook the wavering profiles of the hillsides as one behind the other they ran down toward the winding river. The first sketch was pretty crude, but by coming back to this neighborhood several times I came gradually to realize some of the underlying elements of the problem, so that finally, after various trials, I produced a pencil sketch that later brought to my family and friends at home some faint suggestion of the magic of that scene in distant Africa.

In such a country, with so much to see and record, the time passed quickly; nevertheless, we were all uneasy at the many delays that lay between us and our real objective, the gorilla forests. Even after Raven and McGregor arrived a few days later, it proved exceedingly difficult to secure another camion to carry us and our equipment up into the mountains.

On other occasions I strolled along the shore of the lake, west of the promontory or peninsula, chiefly for the purpose of examining the rocks which were exposed there. On the way I passed through the native village where the brickyards are. In front of one of the houses were several small children, one tiny one crying and a larger child jeering at it, just as white children do. From this and other examples I learned that the natives are very sensitive to ridicule or to the feeling of shame. This is one of the chief means by which the individual is forced to adopt the standards of the tribe, just as among whites. But in general, while older children may jeer at the younger ones, they are amazingly good to the babies, and mothers frequently hand over their babies to be carried around by tiny boys, who soothe them and look after their needs with the greatest faithfulness.

Going beyond the fine Belgian hospital for the natives, I walked along the lake shore to examine some rocks which had been exposed when the road was cut. Here were large irregularly hexagonal basaltic columns projecting from the cut surface of the hill. As they evidently belonged to the same general class of rocks as those that form the palisades of the Hudson River near New York and the basalts of the Giant's Causeway in Ireland, their presence here confirmed my suspicion that at least part of these

mountains had been formed from huge molten sheets that had forced their way up from below at the time of those great disturbances, the effects of which we had seen on the journey from Uvira. An inspection of this cut bank seemed to reveal somewhat of the mode of formation of the larger crystalline columns and of the small nodules of similar rock which had been broken up to form the road near by. For between and around the more perfect cylindrical columns were many abortive or imperfect balls of rounded form, each one arranged in its own concentric wrappings, as were also the big columns. After returning home and referring to authorities on the subject, I find that the explanation is somewhat as follows. Apparently the big columns had solidified from a mass of molten matrix, which, being of large size, had cooled slowly and cracked into more or less perfect hexagonal columns. The little ovoid pieces were formed of the same material in the interspaces between the big ones. The main joints that primarily broke the mass into prisms were due to cooling and shrinking. The onion-like wrappings around both big and little pieces were the result of slow weathering from the surface inward. Some of the basaltic columns had evidently been removed and one very large one set up in the market-place at Bukavu.

Now that I recognized the peculiar appearance of this hill containing broken fragments of such palisade-like material, I could and did recognize similar hills in other places in these mountains, which upon inspection proved to be composed of similar material.

From such observations I was constantly attempting, but in vain, to read the riddle of the geological history of this country, although, without the special counsel of an expert petrographer, I realized that such amateur interpretations would serve at most only to stimulate interest in the following questions: Did these basalt sheets push themselves into this locality during the cycle of activity represented by the still active volcanoes north of Lake Kivu, or did they, like the Palisades of the Hudson River and the other trap sheets of New Jersey and Connecticut, belong to a far earlier age, such as the Jurassic or Triassic? And were they connected with the formation of the Great Rift valley by a system of block-faulting more or less similar to that seen in the Connecticut valley?

Another day I walked along the shore of the lake, east of the promontory, past the very orderly red parade-ground of the barracks. In this district the Belgians have planted thousands of quickly growing eucalyptus trees, a tree originally imported from Australia but now supplied in great numbers by the Botanical Gardens at Eala on the Congo River. The leaves of eucalypts, being held slanting to the sun, let the light through as do the slats of a Venetian blind, lighting up the space beneath them in a way that reminded me of the great eucalypt forests in Australia. The wood derived from them will be very useful in this woodless region, where all the hillsides are bald, especially as near by there is a large school for teaching carpentry to the natives.

After several days Raven and McGregor arrived on a camion coming from Uvira, with all the baggage necessary for our trip into the gorilla country, the rest having been stored away in a government building at Uvira. We were all eager to get off into the field, but although we had been told there would be no difficulty in hiring a camion at Bukavu, diligent inquiries at the several companies that owned them failed to reveal any except at exorbitant prices. We were then only twenty-seven miles away from the edge of the "gorilla forest," and a couple of hours should be sufficient for a camion to take us there with our three servants

and all our voluminous equipment. The porters which we would need in the mountains were to be found near the agricultural station at Tschibinda. In Africa we soon learned that long delays in transit were absolutely unavoidable. Meanwhile, however, I was free to continue my local explorations.

Soon after the arrival of our partners from Uvira I led them all out to my favorite scenes of the winding valley of the Ruzizi River, where they took moving and still pictures of the falls and rapids. These falls are wide but not very steep; they break into rapids and then make another short plunge. The natives catch fish in traps which they put out from the small island just below the falls. This island consists of an irregular mass of black crystalline rock; it divides the river in two, the rapids being on either side of it. A little way down the river is another small jagged, rocky island, upon which were many white herons and snake-birds. Doubtless the herons were attendants upon the cattle near by, while the snake-birds were resting from their fishing flights above the lake. Across the river beyond this island I saw seventeen beautiful Kavirondo cranes leisurely stalking about near the shore. There were a few long-horned cattle in this immediate neighborhood and some goats; hardly a blade of grass was in sight. But there were plenty of cattle-ticks and I soon had my first personal introduction to these pests.

Meanwhile Dr. Engle, who had entered with enthusiasm into the game of picking up the Swahili language, had engaged a boy named Matambele, as we needed at least one more servant, and had begun to ask Matambele the names of things and check up with the Swahili dictionary and grammar. Unfortunately this had been designed to teach the classic Swahili of the standard translation of the scriptures and was different in many details from the current "Swahili" of the Tanganyika mountains.

Matambele was a comely-looking boy about sixteen years old. He had come from Ruanda, northeast of Lake Kivu, hence from the direction of the "cattle-breeding aristocracy." He had the long slender legs of the Nilotics, with the very large luminous eyes of the type which seemed to us specially numerous on the west shore of Lake Tanganyika. He had been well taught by an Englishman and all-in-all was an excellent, intelligent and willing servant, who eventually went with us as far as Stanleyville. Besides all this he proved to be very amusing in many ways of which I shall speak later.

Raven and McGregor brought three other boys with them from Uvira: the lanky cook Poussini, the short, round-faced Musafiri and the burly Behongo. Poussini was perhaps twenty-two years, the others were youths in their late 'teens.

A day or two later I went down to a little hamlet of fisher-people on the lake shore and hired a man to take me out in his canoe for the afternoon, for the purpose of paddling out to the place where Lake Kivu overflowed into the Ruzizi River. The poor chap didn't realize what he was in for when my black boy (Poussini) and I climbed into his piroque and sat down. We stayed fairly near the shore, as I knew that Lake Kivu was subject to sudden squalls.

How pleasant it was to glide along, almost without a sound! There goes a kingfisher, poising in the air before he dives; and there, with powerful strokes, a long-necked snake-bird (*Plotus*) closely allied to our American species. Many weaver-birds twitter about the long reeds on the shore and once or twice a great heron goes by. We slip past many a hill covered with plantations of coffee and sisal and millet and enter first one bay and then another. One gets the impression that the lake includes many drowned fiords. Down each fiord I look to make absolutely sure that the elusive Ruzizi River is not sneaking off somewhere from

—*Photograph by E. T. Engle*

MATAMBELE'S SMILE.

the distant end of the fiord. Finally, late in the middle of the afternoon, we pass around the great wooded promontory behind which, as I had inferred from the distant view, the Ruzizi River should be starting on its troublous journey toward Lake Tanganyika. But peer as I would toward the concave lower end of this long bay, I could not see the river flowing away from it. It was getting late and the wind was against us and I wondered how long the poor knave with the paddle would hold out. Once in a while, when the breeze was stiff, I handled the second paddle myself, mostly, however, as a gesture of encouragement, as I was not used to the native method and the canoe persisted in wayward tendencies; so after a while it seemed more in keeping with my official status as commander of the craft and as a representative of the conquering and parasitic white race to let somebody else do all the work. My black boy sensibly disclaimed all knowledge of paddling and when I made him try it he amply proved his statement. Regretfully then I gave the order to return, which in spite of linguistic obstacles, was readily understood by our paddler.

On the way home we stopped at a near-by island, pushed our canoe into the high reeds around the shore and climbed a long hill. There I had a satisfying view of islands, mountains, lake and sky —of everything in fact but the Ruzizi River, which was meanly lurking behind a screen and would not come out to be identified. By this time I had no doubt fully convinced both the owner of the canoe and my personal boy that I was some weird kind of lunatic, with a dangerous tendency to get lost in an inconvenient place a long way from the nearest meal. However, the blacks are used to the inexplicable ways of the whites. Their job was to go along and to get me back home as soon as I would let them, so neither side thought out loud, or if they did, the other side couldn't be sure there was anything personal being said.

Our canoe was under the thick bushes beneath a steep bank, while the island itself was covered with millet, which sprang back into place after we passed through it. After wandering around on the opposite shore of the island, I would under these circumstances have had small chance of finding my way back directly to the canoe, as I have an exceptionally low "bump of location," but I said nothing, as I felt confident that the owner of the canoe would lead the way back for us without any hesitation, which he did. So we climbed down into the canoe and started homeward in the slanting rays of the sun.

Soon our boatman spied some of his village folks seated comfortably in their boat in a quiet nook, having a bit of supper before starting out for the evening's catch. As we came near I was surprised to see a pot boiling in the middle of the canoe and a fire under it. The ingenious natives, who are masters in the art of controlling fire, had made a small fire in

a large clay basin, which in turn rested on stones. This completely protected the charred inner surface of the canoe. In addition to the fish that was in the pot, they had another fish in the canoe. It was a good-sized cichlid (about seven inches long) and naturally I enjoyed examining it and working its jaws and gill-covers. My boy intimated to me, however, that it wasn't worth much, as he had not yet learned that to his queer white masters the edibility of fish and other animals was only a minor consideration. After a brief and strangely moderated colloquy, during which our boatman borrowed a bit of tobacco from his neighbors and puffed fiercely on his pipe, he was evidently refreshed and ready to proceed. So we pushed off silently from the reeds and waved good-bye to the neighborly savages.

Farther on we came to a party of old and young men in a large canoe, who were headed out toward the fishing-grounds. After a rather brief outburst of jabbering a powerful youth got into our canoe to handle the second paddle, and thereafter we fairly flew homeward in the twilight. Arrived at the steep bank near the hotel I gave our boatman pay beyond his most avaricious dreams (equal to forty-five cents) and also gave a present to the "second paddle." Out of all this I emerged with a lasting infatuation for Lake Kivu and a firm resolve to dig that old river out of his hole if it took the rest of the summer.

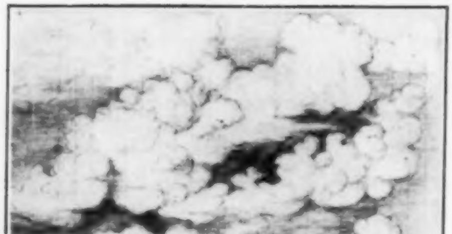
The next day Raven and I went over the hills to the place where the weasel-like Ruzizi ought to have issued from the lake; although it tried some clever dodges, almost doubling on its tracks and hiding itself behind innocuous-looking slopes, we finally cornered it and tracked it to its lair. But even now I can't clearly see where and how it fooled me the day before.

On this walk we passed through a field containing some long-horned native cattle and many of their attendant white herons. I made a few rough sketches and Raven got what proved to be an excellent view of one with enormous, nearly vertical horns and well worthy of a place beside the long-horned cattle of the Pleistocene epoch.

By this time the camion which we had been wooing assiduously for the past

—*Photograph by H. C. Raven*

PRIZE LONGHORN AT BUKAVU.



—*Sketch from Author's Note-book*

WAVE-LIKE MOUNTAINS AND CLOUDS NEAR TSCHIBINDA CAMP.

week allowed itself to be caught and loaded with our voluminous equipment, to say nothing of ourselves, four boys, the Portuguese commandant of the craft and his boy. Meanwhile we had had the great pleasure of meeting at the hotel Dr. and Mrs. Bingham, psychologists of Yale University, who were on their way to the Parc National Albert to study gorillas in the field.

At 4:30 on the afternoon of August third our palavers with the owner-bandit of the camion were, as we fondly thought, completed, so we bade good-bye to our kind host and hostess and to our American friends, all climbed aboard and the order was given to shove off.

Our destination was Tschibinda, in the mountains northwest of Bukavu, only twenty-seven miles away as the crow flies, but with some eighteen hundred feet to climb, up to sixty-seven hundred feet of altitude. In our final choice of Tschibinda as a base for our field studies of the Mountain Gorilla we were influenced by several considerations. It was the nearest spot that was relatively accessible from Bukavu, in which Mountain Gorillas were credibly reported to be fairly common. Also, Raven had received a cablegram advising us to go there, from Dr. Harold J. Coolidge, Jr., who had secured two gorillas there for Harvard University. Again, the roads around Tschibinda were good, so that the difficulties of getting a four-hundred-pound gorilla out of the surrounding forests, while formidable, seemed not unsurmountable. Finally, there was an extensive agricultural experiment station at that place, where in all probability we could obtain porters and a convenient site for a camp.

So as we rumbled along the road on the shore we rejoiced that after so many trying but inescapable delays, we were at last nearing a spot where there was a reasonable hope of seeing living gorillas in the field.

As far as we could see were wave-like mountains, all bare of forest but with occasional patches of banana plantations and native villages. Whenever the road cuttings were deep I could see that under the thick brown and reddish mantle of soil there were outcrops of the basaltic or nodular volcanic rock I have described above.

After a while we turned away from the lake and began to zigzag our way up long grades over the bare hills. It was very cloudy and soon after sunset the rain began to sprinkle. At last we passed some kind of settlement in the darkness and then we stopped. Our wily Portuguese said that this was Tschibinda, that the rest of the way up was fearfully steep and dangerous to his camion, that our load was far too great and that we must pay him for making two trips the rest of the way in spite of the enormous price he had exacted for getting us up there. Raven explained that he had understood that Tschibinda was on top of the mountain and that we must go on. After

much palaver it appeared that this place had formerly been called Tschibinda and that the rest of the way really was steep. Finally McGregor and I and two of the boys, with half the load, got off and disposed ourselves along the roadside, while Raven and Engle went on up to the top to make arrangements for the night.

McGregor and I were warmly dressed and had our raincoats, but our boys were half naked. By gesture and example I made them start a fire before the rain got too bad. But the shiftless wretches would gather only a little straw at a time and before long the fire was drowned out. There they sat huddled together, shivering like wet hens with the cold water streaming off them. By the light of our flashlights I piled the baggage up and made them crawl under it. McGregor sat on the baggage in his oilskins, but I, being somewhat dubious about spiders, centipedes, scorpions, to say nothing of big-jawed ants, and mindful of the awkward predicament of the armed knight described in "A Yankee at King Arthur's Court," chose to walk up and down like a sentry.

After an hour or so in the cold rain and darkness it was with no unfeigned joy that we saw the gleam of an approaching camion reflected in the sky; but our joy was short-lived, because our Portuguese driver, now comfortably drunk and somewhat confused and thick of speech, assured us that the road ahead was extraordinarily steep and that he would not endanger his camion and himself by taking our second load up that night. So he parked the camion by the road and we went to the settlement near by, which was named Mulungu; this was the center of the immense agricultural experiment station and here were the residence and headquarters of M. Vanderstok, the general manager. Here we met a Russian youth with a perfect English university accent, an employée of the great agricultural experiment farm. He was Mr. Ditz of Mulungu, with whom we afterward became better acquainted. It was then getting late,

—*Photograph by E. T. Engle*

JUNGLE NEAR CAMP.

and he very courteously offered to get porters to remove our baggage to a safe place, as he feared some of it might be stolen if we left it there over night. He told us also that there were leopards near by and that he would not advise us to sleep on top of our baggage as we had purposed to do. He then got his porters up and took us to a newly constructed storehouse, where later we spread our bedrolls on the floor and passed a very comfortable night.

Meanwhile Mr. Vierstraet, who was in charge of the upper part of this experiment station, located at Tschibinda near the top of the mountain, very kindly came down in his automobile, bringing Raven. By this time we had supped sufficiently on milk chocolate, nuts and oranges. McGregor went back in the car, while Raven and I remained to come up in the morning with the luggage. This we did, without any special difficulty.

I have related these particulars rather fully because it illustrates the kind of unexpected delays to which we were so often subjected. No one, no matter with how much experience in Africa, could make safe predictions as to how long it would take to get to a given place. The only safe prediction was that the unpredictable would often happen.

Utterly unexpected, to me at least, were the delightful scenes that we found on arriving at Tschibinda, near the top of the mountain. Looking down the mountain toward the east we could see one mountain wave after another, with silvery Lake Kivu in the middle distance and receding ranges on the other side. Turning toward the west, in the near background, dominating everything else, was the upper part of the mountain, clothed in a dark green forest where gorillas roamed freely. In the middle distance was a jungle of vines and dense underbrush, sprinkled all over with magenta-colored morning-glories and many other flowers. Immediately around us was a beautiful garden with many flowers from Europe, in front of the pleasant residence of Mr. Vierstraet and his charming family. Another pretty feature was a high mound of rocks with a meteorological station on top of it. Here and there were *Erythrina* trees, almost leafless, but with silvery yellowish trunk and branches, the latter bearing many large and brilliant red flowers, making the trees remarkably conspicuous as they stood alone in the otherwise open spaces. A proud Cavirondo crane with his jaunty aigrette added another Japanese touch to the scene.

In an attractive spot near his house Mr. Vierstraet invited us to make our temporary camp until we could have time to choose a site even better, and Mr. Vanderstok, the general manager, gave us the freedom of the whole experimental station, covering many square miles. The best feature of all was that Dr. Harold J. Coolidge, Jr., had secured his two gorillas in the forest right near the house and that not long ago gorillas had been seen by the natives near by.

After a morning spent in making camp, all four of us went for our first stroll in the forest back of the house. There had been much cutting, many of the larger trees having been taken out, so that the underbrush that had sprung up was extraordinarily dense and tangled. But to us, who had just come from a nearly treeless country of open plains, the Tschibinda forest seemed riotous in its luxury and color and I regretted my lack of botanical knowledge, which would give some insight into the infinitely confused struggle for a place in the sun of all these contending organisms. Many birds mocked us with their calls. There was one which kept up such a monotonous and regular "Toot-toot, tooty-toot!" that many days passed before I could convince myself that the sound really was not due to some squeaky

wheel, as of a pump, perhaps connected with the agricultural station. Another insisted on screeching "Ktwenty-eight, ktwenty-eight, ktwenty-eight!" in a mechanical, harsh and insistent way that seemed inappropriate and fanatical in such a jungle of anarchic form and color.

But while we were still within sight of the brown fields of the farm Raven stopped and pointed to something alongside the path. A young banana plant had been bitten off and at its base was a large bolus of greenish fecal matter. "Gorilla!" said Raven, and gorilla it was. None of us needed to see a gorilla in the flesh to visualize the animal that had left this indubitable trace of its presence perhaps less than a week ago. Several times that afternoon we saw old excrements of gorillas along the path. The whole region became invested with an enhanced interest and importance; for after so many months of travel and effort we were at last (August 4th) within striking distance of our objective.

From evidence gathered on that and succeeding days it was plain that the gorillas traveled about in small groups of varying number; also that they consumed an enormous amount of vegetation, chiefly succulent stems which they cut with their teeth, often drawing the stems across their mouths, stripping off the green juicy layer and throwing down the long white stems. They made rude beds on the ground and in trees simply by sitting down and bending the branches around them; finally, it was evident that they did not stay in one locality but roamed about at random.

But gorillas were far from being "as thick as blackberries" in this or any other locality we visited, and more than two weeks of patient and persistent hunting elapsed before Raven secured Gorilla No. 1.

Meanwhile the first thing was to choose a site for our regular camp and get everything ready for the reception of our gorillas, and also to begin the work of securing the footprints and photographs of natives by means of the apparatus provided for us by Dr. Morton.

(To be continued)

THE WORLD'S GOLD RESOURCES

By Dr. ADOLPH KNOPF
PROFESSOR OF GEOLOGY, YALE UNIVERSITY

Present Status of Production

Gold is now being mined at the highest rate in history, and the world's output for the year 1934 reached 27,475,000 ounces or, in dollars, more than 960 millions. The Presidential decree of 1934 which raised the price of gold from $20.67 an ounce to $35 has made the statistics of world output no longer directly comparable with those prior to the decree. For the output of gold, unlike that of other mineral products, was always reported in dollars, because gold had a fixed price of $20.67 an ounce.

From 1890 onward the world's annual output mounted steadily till 1915, when it attained $470,000,000. Although it reached a peak in that year, the increase during the previous 10 years had been small: in other words, essentially an equilibrium between resources and production had been established. The World War then caused the purchasing power of gold to diminish. Everything the miner used increased in price, but the price of his gold remained the same. Consequently, the world's production soon began to dwindle. In the United States it dwindled steadily from the all-time peak of $101,000,000 to $45,000,000 in 1927, and world production declined to $320,000,000, almost exactly proportional to the decline in the purchasing power of the dollar.

The low point in the world's output of gold was reached in 1922, but it has been increasing continuously since. In the last few years, after so many countries went off the gold standard, production has been accelerated. The world price of gold is determined in the London market, and is now the highest in the history of gold (140 shillings per ounce).

During recent years most of the world's gold has been produced by three countries: South Africa, the United States and Canada. In 1934 Russia forged ahead to second place and Canada fell to fourth place. The increased price of gold has reacted on production in a rather unexpected way in two of the leading countries—South Africa and Canada—it temporarily caused a decline in output, as measured in ounces; but in the rest of the world it has increased the output, and 1934 shows the record output of 27,475,000 ounces—an increase of 4,000,000 ounces over the peak of 1915.

More than half the annual supply of newly mined gold in recent years has come from South Africa — from the world's greatest gold field, the Rand. In all forecasts on the future of the gold supply it must be remembered that half the annual supply is furnished by a single field, the geology and technical features of which are well known. In fact, the conditions in it are such that predictions concerning it can be made far more accurately than for any gold field in the world.

Mode of Occurrence of Gold

When we consider gold in its geologic aspect, the first striking feature is that it is widely distributed over the globe, but everywhere in small quantities. If we were to put together all the gold mined since 1492, a little over 1,000,000,000 ounces, it would make a cube having an edge 38.5 feet long. Half of this gold has been mined in the last 25 years.

Gold occurs in so many places that the popular rule was long ago formulated that "Gold is where you find it." This explanation is thrown at one in all our gold-mining camps, and is variously at-

tributed to Job and to Mark Twain. Modern geology can answer the question of what determines the distribution of gold somewhat more satisfactorily than could those authorities.

Gold occurs in two ways the world over. Most simply, it occurs as tiny flakes and grains of native metal in the gravels of streams—as placers. In this mode of occurrence the gold is easily found: all that is necessary is a pick, a shovel and a pan—even a frying-pan will serve. How easily placer gold can be traced is indicated by the fact that a tiny flake of gold worth one cent can be pounded into 2,000 flakelets and a single one of these "colors" can be caught and recognized in the miner's pan. After being found, placer deposits are easily worked, requiring little capital outlay to work them profitably in the case of the richer deposits. The history of most gold-mining districts is therefore that the prospector found gold in the river and creek beds, that these deposits were soon worked out, and that attention was then directed to finding the veins and lodes from which the streams had obtained their gold.

Extraordinary mechanical ingenuity has been developed to work the leaner, low-grade placer deposits. This has reached its acme in the gold-digging dredges of California. These have attained such efficiency that they can work gravel carrying as little as 10 cents to the cubic yard. The bigger dredges had been digging as deep as 60 feet below water level, but with the new price of gold they are being reconstructed so as to dig to depths of 110 feet or more below water level.

Because of the ease with which placers can be found, all those in the civilized portions of the globe were found long ago and have been largely worked out. Only in the out-of-way places can we anticipate any discoveries. The gold output of Alaska in the past 30 years has been largely placer; and the recent increase of the Russian output is chiefly from placers, though here again it is not so much owing to new discoveries as to the results of the energetic mechanization and modernization of equipment.

A very up-to-date development of a placer field has recently been accomplished at the Bulolo field in New Guinea. To open up this field would have required the building of a road that would not only have been 90 miles long but also would have had to cross a mountain range 4,000 feet high. To save this expense it was decided to bring in all equipment by airplane. Pieces up to 7,000 pounds were transported, and two dredges are now operating very successfully.

To sum up the placer situation: the world's gold placer deposits are nearly exhausted, and at present they supply only 10 per cent. of the world's new gold.

Veins and Lodes

The bedrock sources of gold—the veins and lodes—are now the mainstay of the gold-mining industry and hold the bulk of the reserves.

Gold veins occur in the earth's crust only in those portions in which in the geologic past there has been igneous action. By igneous action is meant the rise of molten rock-matter from deep in the earth to higher levels in the crust or to its eruption at the surface. During many of the so-called revolutions in the earth's crust, which have occurred from time to time during the long span of geologic time, the strata of certain long narrow belts are bent and closely crowded together so that they stand vertically. Enormous masses of molten granite are generated: in our own Sierra Nevada, during the mighty revolution near the end of Jurassic time, say a hundred million years ago, thousands of cubic miles of molten granite worked their way upward into the higher levels of the crust. As these masses cool and

solidify they give off their dissolved gases, which rise toward the earth's surface and eventually appear there as hot springs. If they carry gold, this gold is deposited on the way up, along with quartz, thus forming the most common type of gold deposit, the gold-bearing quartz veins. A series of more or less closely spaced parallel veins, together with the intervening rock matter, is termed a lode. Such veins and lodes occur in the borders of granite masses or in the rocks surrounding the granite masses. Practically it has been found that veins thus formed supply most of the world's gold. Many of them are remarkably persistent in depth, and man has gone down on these veins into the earth's crust as deep as 8,000 feet vertically below the surface—far deeper than in his quest for any other metal.

Spectacular gold deposits have sometimes been formed in connection with the outbreak of molten rock matter at the earth's surface; in short, in connection with volcanic outbursts. These deposits generally give out at shallow depths, at 1,000 feet or less. The distinction between these veins and those formed in connection with deep-seated igneous rock is therefore of very practical interest.

It is an interesting fact that most of the world's great gold mines are in Pre-Cambrian rocks—in South Africa, in Ontario, in India, in Brazil and in our own greatest gold mine, the Homestake in South Dakota.

The gold in sea water is of perennial interest. When in 1921 the Reparation Commission demanded of Germany 132 billion marks (=50,000 tons of gold) it seemed fitting, as Haber says, for the chemists to see whether the immense reserve in the ocean might not be made available. Arrhenius in 1903 had estimated the gold content as 6×10^{-6} gm. per kilogram. As the result of his careful work Haber reduced this to 1/1500 of Arrhenius' estimate, which is far below the limit of commercial availability. The gold was found to be present in the sea mainly in coarsely dispersed form, *i.e.*, not in solution but entangled with suspended material and the plankton. Haber predicted that the deep-sea sediments will therefore be relatively rich in gold.

Recently a minute amount of metallic gold has actually been isolated from sea water as a by-product in the recovery of bromine, but at a cost of fifty times its value.

Resources of the United States

The gold resources of the United States are well known, and we can therefore make some confident predictions about their future output. The more important placer deposits have been found and are largely worked out. There is only one important exception: the Tertiary auriferous gravels of the Sierra Nevada—the dismembered relics of a system of dead rivers. About one billion dollars are locked up in these gravels, but the working of these gravels has been practically suspended since the Anti-Debris legislation of 1884. There these auriferous gravels have lain the past fifty years, an irresistible temptation to the miner. I have wondered how long before he would overcome the legal and other obstacles that hinder him from working these deposits. Surely enough laws have recently been passed by the legislature of California, conferring the power of forming placer-mining districts in analogy with irrigation districts, with the right of eminent domain. These placer-mining districts will build concrete restraining dams to impound the gravel tailings from the gold washings, and there is no doubt that California is in for a revival of this form of hydraulic placer mining.

How well the forty-niners and their successors depleted the present streams of their gold is shown by the recent experience of the hordes of unemployed

who have gone into the California hills to try their luck at placer mining. During 1932 and 1933 there were 12,000 to 15,000 placer seekers, but their average reward was $40 apiece for the season of 1932.

The last finding of a major gold field in the United States was the Cripple Creek district, Colorado, as long ago as 1890. The veins here are in the throat of an old volcano and to date have yielded $400,000,000. The present yearly output has fallen to a fraction of what it was at zenith, in 1900, but is now on the upgrade.

Early in the present century spectacular gold finds were made in Nevada, notably at Goldfield. Here in the desert sprang up almost over night a full-fledged city, and for a few brilliant years Goldfield had the most productive gold mine in the world. The district produced about $100,000,000 and was then nearly worked out.

The most productive gold mine in the United States is the Homestake, in the Black Hills of South Dakota. Long famous as a highly successful enterprise on low-grade ore ($3 to $4 a ton), the grade of its ore was raised to $6 to $7 a ton by the application of geology to the problems of mining and then to $10 to $11 a ton by the new price of gold. It is now paying dividends at the rate of $3 a month.

Alaska has yielded $400,000,000 since 1880, but does not seem destined to give us a major gold field. The most notable feature of its gold-mining industry is that in the Alaska-Juneau mine it has the premier low-grade mine in the world. At this mine has been achieved the unprecedented feat of profitably mining ore carrying only one pennyweight to the ton. Although this great technical achievement is not likely to be repeated at many places, owing to a combination of favorable circumstances at Juneau, still it remains a goal at which to aim.

It appears that no major field has been discovered in the United States during the last 30 or 40 years, and the finding of another in the future is unlikely. However, the new price of gold has converted much marginal and submarginal material into ore, and it is probable that the value of the domestic output will in a few years exceed that of the zenith year (1915)—$101,000,000.

In "Gold Resources of the World" it was estimated that the output of the United States from 1928 to 1950 will be between 35,000,000 and 108,000,000 ounces. It now appears that the output will more probably reach the maximum than the minimum figure.

Future of the Rand

The Rand is the world's greatest gold field. It has yielded more than $5,000,000,000 on the old valuation of gold—nearly $9,000,000,000 on the new. In recent years it has been supplying more than half the world's new gold. Another way of illustrating the Rand's importance is that 29 of the 43 leading gold mines of the world are in the Rand. In any forecast of the future of gold, the future of the Rand is the most important factor.

The gold occurs here in a way that is nearly unique. It occurs in what was once a thin bed of gravel that had been spread horizontally over the earth's surface. In the course of time the formation in which this bed is intercalated was bent deep down into the earth's crust—into a syncline, as the geologists say—and the gravel became cemented to a hard rock, to a conglomerate. During the 50 years of mining, the conglomerate bed has been followed ever deeper into the crust. More than 220 square miles of the bed, averaging 2 feet in thickness and 7 pennyweight to the ton, have been mined. Not fabulously rich, it will be seen; its great output is the result of technical efficiency. Depths of 8,200 feet have now been attained.

Mining at such great depths entails

special technical problems. The two most important are the increase of temperature with depth and the danger of rocks bursts. A depth of 7,500 feet was regarded a few years ago as the economic limit of mining, but already some of the mines have reached a depth of 8,200 feet. Fortunately the Rand is favored by an extraordinarily slow rate of increase of rock temperature—1° F. for every 212 feet of depth. But at 8,000 feet depth that means a temperature of 97°. That temperature, coupled with the high humidity (due to free use of water to keep down silicosis-producing dust), causes fatalities by heat stroke. Even for the "acclimated" worker it greatly impairs working efficiency: to about one half, I should say. Consequently, the Robinson Deep mine is now building the largest air-conditioning plant in the world in order to supply refrigerated air to the bottom levels of the mine.

An even stronger obstacle to mining at great depths than the difficulty of keeping the temperature down is the difficulty of supporting the workings. At great depths the rocks, especially the more brittle kinds, develop the dangerous feature of spalling off fragments. Pieces fly off with explosive violence, not only causing fatal accidents but also making it difficult to keep open the workings. It is probable that the difficulty of support of the workings rather than the problem of ventilation will determine the ultimate depth of mining.

A few years ago it was generally accepted that the Rand would be practically exhausted by the year 1950. The high price of gold has, however, greatly altered the complexion of things. It has doubled the prospect of the life of the mines now working and has made profitable vast quantities of submarginal ore. The immediate effect of the high price of gold on production has, however, been the opposite of what might on first thought have been expected. The amount of ore mined in 1933, it is true, increased, but the yield per ton (5.84 pennyweight) decreased, so that, although the value of the output was larger, the number of ounces of gold produced was smaller. By August, 1934, the average content had decreased further still to 4.85 pennyweight a ton. In other words, lower grade ore is being mined, and the mines are thus conserving their resources. Dividends, however, gratifyingly increased by 50 per cent. Taxation, on the other hand, has increased 440 per cent. since 1932. As long as present economic conditions persist, the exhaustion of the Rand is so far off as not to be a matter of much present importance.

Conclusions

The gold resources of the world are large, but they can not be measured with any approach to accuracy. Only the amount of gold in some of the placers can be roughly appraised. The placers of the United States are mainly in California and Alaska; for the remainder of the world, chiefly in Siberian Russia. From the Russian placers, as the result of the present energetic campaign of the Soviets in mechanization and modernization of equipment, we may expect to see a steadily increasing output.

It may be of interest to consider some earlier forecasts of the future of gold. During the world war the gold production began to fall alarmingly. An able committee appointed in 1918 by the Secretary of the Interior to study the gold situation in the United States reached the conclusion that "the output of the world seems to have passed its zenith and to be on the decline." This conclusion held for four years. In 1922, however, the world output reached a low, and from then on it began to increase. In spite of the recovery, however, most authorities remained highly pessimistic as to the future of gold because of their belief in the early exhaustion of the

world's principal deposits. Kitchin in a report to the League of Nations in 1930 had the astonishing courage to forecast each year's output till 1940. For 1934 he estimated a yield of $403,000,000. Loveday in a later report to the League of Nations thought Kitchin's figures too optimistic and estimated an output of $390,000,000 in 1934 and $314,000,000 by 1940. Actually the 1934 output was $570,000,000 at $20.67 an ounce, or $962,-000,000 at the new price of gold.

It is the new price of gold that has completely changed the situation. In all countries of the world the immediate effect has been to raise submarginal and marginal gold-bearing material into ore, and in all countries, except the Rand and Ontario, the output in ounces has increased. In those two regions the large mines preferred to mine lower grade ore and save the better ore for the future. But much capital is pouring in, and in two or three years the production from new mines and milling plants will swell the output.

Improvements in mining methods and metallurgy will aid to some extent, although these have already been brought to a state of very high efficiency. Improvements in transportation facilities, as exemplified by the airplane, which has accelerated the opening up of such inaccessible regions as the interior of New Guinea and the area of 2,000,000 square miles of Pre-Cambrian rocks north of the Great Lakes, known as the Canadian shield, will lead to new discoveries. Rich placers can not be expected to be found, but lodes will be found, which will at least counterbalance the exhaustion of those now being mined. Geophysical methods of prospecting will help in finding new deposits, as brilliantly demonstrated by the discovery of the first-class deposit at Boliden under the glacial drift of northern Sweden.

The history of gold production during the last twenty years appears to demonstrate that the main factor in determining production and reserves is the purchasing power of gold. We may therefore anticipate that the world output in a few years will exceed $1,000,-000,000, and will remain at that figure for some years. When it reaches that figure, an equilibrium, as it were, will have been attained between production and the present purchasing power of gold, just as earlier, in the period culminating in 1915, an equilibrium between production and purchasing power of gold at that time had been established. If and when the purchasing power of gold declines, the world output of gold will decline with it.

Selected Bibliography

Report of a Joint Committee appointed from the Bureau of Mines and the U. S. Geological Survey by the Secretary of the Interior to study the gold situation: *U. S. Bur. Mines Bull. 144*, 84 pp., 1919.

Haber, F., "Das Gold im Meerwasser," *Zeitschr. angew. Chemie*, 1924.

Kursell, H. A., "World's Gold Supply Soon to Dwindle," *Eng. and Min. Jour.*, July, 1930, pp. 347–350.

"The Gold Resources of the World": an inquiry made upon the initiation of the Organizing Committee of the XV International Geol. Congress, South Africa, 1929, 457 pp., 1930.

Graton, L. C., "Future Gold Production—the Geological Outlook," American Inst. Min. and Met. Eng., *Trans.*, pp. 534–557, 1931.

Truscott, S. J., "Problems of Mining at Great Depths," *Nature*, Vol. 132, pp. 229–231, 1933.

THE FIRST OFFICIAL PHOTOGRAPHER

By CHARLES MACNAMARA

ARNPRIOR, ONTARIO, CANADA

NOWADAYS the official photographer is such an indispensable member of every well-organized exploring party that it is interesting to look back to the first of these important personages and learn something of his experiences and adventures. His name was Solomon N. Carvalho, and he was attached to Colonel John Charles Fremont's fifth exploring expedition to the West in 1853–54, the object of which was to discover practicable passes for a railroad through the mountains at the sources of the Rio Grande. This great explorer's expedition for the same purpose five years before had ended in disaster without attaining its aim. A guide led the party astray, and Fremont, caught in the snow, lost all his equipment, and several of his men perished. Some of the starving survivors were driven to cannibalism before the party reached safety in the settlements of Southern California.

The expedition of 1853–54 was intended to retrieve this failure. Avoiding the fatal route where the guide went wrong before, this time Fremont found the hoped-for passes, which, however, have never been used for a railroad. But again the explorers suffered great hardships, and it was a wretched company that came out of the mountains into a settled valley in Southern Utah and straggled into the little Mormon town of Parowan.

Except for a couple of letters written by Fremont to the *National Intelligencer* in 1854, the only known account of this expedition is in the book by Carvalho published in 1857. The title, spaciously composed in the good old-fashioned manner, promises some exciting reading, but indicates nothing of photographic interest:

> Incidents of Travel and Adventure in the Far West; with Col. Fremont's Last Expedition across the Rocky Mountains: including three month's residence in Utah, and a perilous trip across the Great American Desert, to the Pacific. By S. N. Carvalho, artist to the expedition. New York: Derby & Jackson, 119 Nassau St. Cincinnati:—H. W. Derby & Co. 1857.

But it turns out that the author with the Portuguese name (though he was a born American) besides being an artist was also a daguerreotypist, and it was chiefly in that capacity that he accompanied the expedition.

Carvalho tells us nothing of himself previous to joining the expedition, but some little information may be gleaned from casual remarks in the course of his account. Thus it appears that in his younger days he lived in Charleston, and that at the time of the expedition he had a wife and children, and his parents were still alive. His preface is dated at Baltimore, and he is listed in the directories of that city from 1851 to 1860 as an artist and in charge of a daguerreotype studio. But it was in New York that he met Colonel Fremont, whether by chance or appointment does not appear. At this time of his life Fremont was a great national hero—three years later he was nominated for the presidency—and Carvalho was evidently one of his most devoted worshippers. The daguerreotypist had had no experience of life in the open, and was obviously much more at home in the velvet jacket and fez of the "studio artist" than in the dress of a frontiersman: "I had never saddled a horse myself. My sedentary employment in the city, never having required me to do such offices"—a quotation which gives a foretaste of his style and the occasional peculiarity of his punctua-

tion. He foresaw all the hardships and risks of the journey clearly enough, yet such was his admiration for Fremont that, much to his own surprise, he joined the expedition.

On the 22d August, 1853, after a short interview with Col. J. C. Fremont, I accepted his invitation to accompany him as artist of an Exploring Expedition across the Rocky Mountains. A half hour previously, if any one had suggested to me, the probability of my undertaking an over land journey to California, even over the emigrant route, I should have replied there were no inducements sufficiently powerful to have tempted me. Yet in this instance, I impulsively, without even a consultation with my family, passed my word to join an exploring party, under command of Col. Fremont, over a hitherto untrodden country, in an elevated region, with the full expectation of being exposed to all the inclemencies of an arctic winter. I know of no other man to whom I would have trusted my life under similar circumstances.

Carvalho was rated as an artist, and he took paints and brushes with him, but his principal duty was to be "making a panorama of the country, by daguerreotype process, over which we had to pass"; and the next ten days after his engagement were spent in getting together the necessary materials. Although rivaled by Fox Talbot's calotype, and due for extinction in a year or two by Scott Archer's wet collodion process, daguerreotypes were still exceedingly popular. In London at this date the charge for a "quarter-plate" (3¼ by 4¼ inches) Daguerre portrait was fifty shillings, and for a "half-plate" (4¾ by 6½ inches) eighty shillings. Carvalho is exasperatingly silent on the details of his equipment and work, and says nothing of the size of his plates nor which of the several modifications of the process he practiced. Perhaps such shop-talk was beneath him. But it will be recalled that the Daguerre process consisted essentially in exposing a highly polished and meticulously clean silver plate—usually silver plated on copper—to the vapor of iodine until the silver surface turned a bright golden yellow. This iodized plate was exposed in the camera, the first working methods requiring an exposure of five to thirty minutes, reduced by later methods to as many seconds. Development was effected by subjecting the exposed plate to the fumes from mercury heated in a saucer by a spirit lamp. The image—a positive one—appeared in about twenty minutes, and was fixed in a solution of hypo, the chemical still familiar to all photographers. The plate was washed by carefully running distilled water or boiled and filtered rain water over it. The image was sometimes toned with gold, and most of the daguerreotypes still in existence were so treated. The picture was exquisitely fine, but so tender that it would not stand the slightest touch, and had to be protected with a cover glass. Although daguerreotypes were the first actual pictures produced solely by physical and chemical means, in short the first real photographs, yet the process proved to be a dead end in photography, and the science developed in quite another direction.

And here it may be noted that it was only by a narrow margin that Carvalho gained his distinction as the first expedition photographer. For the next year (September, 1854) an Englishman, Roger Fenton, joined the British forces in the Crimea as the first war photographer. His process was wet collodion, just coming into general use, and his equipment (bulky apparatus was a leading feature of the "wet plate" method) included a covered van and four horses, and 36 large chests containing two large and two small cameras, 700 glass plates of four different sizes, a portable still and stove, chemicals, printing frames, baths, dishes and sundries. Whatever Carvalho's apparatus may have been, it certainly was nothing as ponderous as that.

As this was the first time that daguerreotypy was to be attempted on an exploring expedition, Carvalho's profes-

sional friends were doubtful of his success.

> Buffing and coating plates, and mercurializing them, on the summit of the Rocky Mountains, standing at times up to one's middle in snow, with no covering above save the arched vault of heaven, seemed to our city friends one of the impossibilities—knowing as they did that iodine will not give out its fumes except at a temperature of 70° to 80° Fahrenheit.

How he overcame the "impossibilities" Carvalho does not disclose, but he intimates that he was entirely successful, although at the cost of severe suffering. He belittles neither his achievements nor his hardships, and no doubt both were real enough.

> I shall not appear egotistical if I say that I encountered many difficulties, but I was well prepared to meet them by having previously acquired a scientific and practical knowledge of the chemicals I used, as well as of the theory of light: a firm determination to succeed also aided me in producing results which to my knowledge have never been accomplished under similar circumstances.
>
> While suffering from frozen feet and hands, without food for twenty-four hours, travelling on foot over mountains of snow, I have stopped on the trail, made pictures of the country, repacked my materials, and found myself frequently with my friend Egloffstein . . . and a muleteer, some five or six miles behind the camp, which was only reached with great expense of bodily as well as mental suffering. The great secret, however, of my untiring perseverance and continued success, was that my honor was pledged to Col. Fremont to perform certain duties, and I would rather have died than not have redeemed it. I made pictures up to the very day Col. Fremont found it necessary to bury the whole baggage of the camp, including the daguerreotype apparatus. He has since told me that my success, under the frequent occurrence of what he considered almost insuperable difficulties, merited his unqualified approbation.

Carvalho's relation is more or less disconnected; events are not recorded in the order of their happening and dates are mostly wanting. This article will not attempt a continuous account of the expedition, but will touch principally on incidents of photographic concern, and will pass over buffalo hunts, prairie fires, search for lost horses, contacts with none too friendly Indians, deep snows and cold weather in the mountains, shortage of food and such like occurrences usual to Western travel of the day.

Carvalho left New York on September 5, 1853, and joined Colonel Fremont and others of the party at St. Louis. Thence they traveled by steamboat up the Missouri to the mouth of the Kansas, where the rest of the party was in camp awaiting them.

Now appears a "Mr. Bomar, the photographist," who seems to have been engaged in addition to the daguerreotypist, or at least had been taken on trial. The two craftsmen found quarters in a hotel, and proceeded to put their respective apparatus in working order. Carvalho says "Mr. Bomar proposed to make photographs by the wax process, and several days were consumed in preparing the paper, etc."

The wax process was an improvement on Fox Talbot's calotype process, which, as is well known, differed fundamentally from daguerreotypy in producing a negative from which any number of positive prints could be made—the leading principle of all modern photography. In calotype, sheets of paper were washed over with a nitrate of silver solution, dried, immersed in a solution of potassium iodide and again dried. The paper so prepared could be stored for future use. Before exposure in the camera the paper was brushed over in the dark room with a mixture of silver nitrate, acetic acid and gallic acid. It could be exposed wet or dry, and exposures ran from fifteen seconds to twenty minutes. Development was with the gallo-nitrate mixture used in sensitizing, and the negative was fixed in potassium bromide or hypo. Printing paper was prepared in the same way as the negative paper. The wax process introduced some slight variations in the chemical treatment, but the principal difference was the preliminary wax-

ing of the paper to reduce grain and facilitate printing. For some years the process competed with daguerreotype, but popular taste had been formed on the beautifully fine Daguerre image and did not take readily to the rather coarse and grainy calotype picture.

Although its chemistry was a little more complicated than that of daguerreotypy, it is likely that the wax process with its hardy, inexpensive negative, capable of yielding any number of prints, would have been a better method for the expedition than the daguerreotype with its single, unreproducible, costly and delicate picture. But Carvalho, proud of his skill and jealous for his process, was not going to let any mere photographist supplant him, and he took steps to secure his position.

> I was convinced that photographs could not be made by that process as quickly as the occasion required, and told Col. Fremont to have one made from the window of our room to find out exactly the time. The preparations not being entirely completed, a picture could not be made that day; but on the next, when we were all in camp, Col. Fremont requested that daguerreotypes and photographs should be made. In half an hour from the time the word was given, my daguerreotype was made; but the photograph could not be seen until the next day, as it had to remain in water all night, which was absolutely necessary to develop it. Query, where was water to be had on the mountains, with a temperature of 20° below zero? To be certain of a result, even if water could be procured, it was necessary, by his process, to wait twelve hours, consequently, every time a picture was to be made, the camp must be delayed twelve hours. Col. Fremont, finding that he could not see immediate impressions, concluded not to incur the trouble and expense of transporting the apparatus, left it at Westport, together with the photographer.

The last phrase betrays a certain satisfaction. Yet when the rejected photographer later heard all that happened to the expedition, the satisfaction must have been all his.

Colonel Fremont's reason for deciding against the wax process does not seem a valid one. There was no instantaneous need for the pictures. They were intended to illustrate the future report of the expedition, and it would not have mattered if their completion had been delayed for months, to say nothing of twelve hours. And to acquit Carvalho of intentional misrepresentation, it must be supposed that he did not understand the wax process when he asserts that it would have been necessary to delay the camp twelve hours every time a photograph was made. It is not on record that the fully sensitized paper would keep indefinitely, but it was good for some days at least. The "wax processer" could prepare his paper at night, and have it ready for use during the next few days as required. The negative, again, could be developed at night; and prints, of course, could be made at any time, months or years later. However, the photographer was discarded, and dependence for pictures was now all on the daguerreotypist.

About September 21 the explorers set out by pack train up the course of the Kansas River, and after traveling a week or so, encamped near Salt Creek until the end of October, awaiting the return of Colonel Fremont from St. Louis, where he had been obliged to go for medical treatment.

Carvalho's troubles began in the first few days of travel. Very early the baskets holding his apparatus were broken and rendered useless. Colonel Fremont may have held the daguerreotypist in high esteem, but the mule drivers emphatically did not. They evidently regarded him and his unwieldy baggage as common nuisances, and it was more than likely that they had broken the baskets in the hope that the apparatus would be abandoned.

Carvalho managed to find box covers enough to make cases for his materials, but he says—almost unbelievably—that the expedition lacked such elementary

tools as a saw and a hatchet. To put the cases together, he and a friend had to ride ten miles with the boards to a frontier village, where they borrowed the necessary tools from a blacksmith. Here they shaped the boxes and reinforced the joints with rawhide. They returned to the camp each with a huge box before him on the saddle. Carvalho's style is much too genteel to permit a literal statement of what the mule drivers said when they saw him coming back with the boxes. What we may be sure was the full Rabelaisian flavor of their remarks is entirely wanting in his polite record:

> Nobody in camp knew my errand to town, and I shall never forget the deep mortification and astonishment of our muleteers when they saw my boxes. All their bright hopes that the apparatus would be left were suddenly dissipated.

But the muleteers were not yet defeated. Later on they took to "accidently" forgetting the apparatus on the trail. The tin case containing the indispensable buff for polishing the silver plates Carvalho twice found dropped on the road. The buff lost, all the rest of the apparatus was useless. Another time the keg of alcohol was missing, and when discovered back on the trail, half its contents was gone. But Carvalho's fortitude remained unshaken, and he prides himself on his perseverance and watchfulness in preventing the loss or destruction of his equipment.

On Colonel Fremont's return at the end of October the march was continued up the Kansas. The water in this river was too turbid to wash the delicate Daguerre plates, and final finishing of the pictures had to be deferred until the crystal streams of the Rockies were reached. Immense herds of buffalo were encountered all along the way, and when crossing the divide between the Kansas and Arkansas rivers, Carvalho tried to photograph some of them in motion, but failed. The day of instantaneous photography had not yet arrived. A Cheyenne village on the Arkansas afforded many pictures, and the daguerreotypist won great fame among the Indians by changing their brass bracelets and rings in an instant to glittering silver by wiping them over with mercury. And when he demonstrated "fire water" by lighting with a match some of the alcohol he used to heat his mercury, he was universally hailed as a big medicine man.

They pursued their way up the Arkansas, eventually branching off to follow a tributary, the Huerfano, in the present state of Colorado. Here Carvalho was instructed to make several views of a remarkable sugar-loaf hill, Huerfano Butte. For this purpose he remained behind with four men and several pack animals. By the time the views were taken the main body was four hours ahead, and Carvalho's party failed to reach them that night. To balance the daguerreotype boxes, the mules had been loaded with all the buffalo robes and blankets of the camp, so the party was well supplied with bedding, but they had nothing to eat as all the food was with the main body. The weather turned intensely cold, and both parties passed a bad night, one suffering from hunger and the other from cold.

It was not far from here that the former expedition had taken the wrong route with such disastrous consequences. Colonel Fremont pointed out the fatal place, and Carvalho took pictures of the distant scene. Making their way through the Sandhill pass into the San Luis valley, the explorers came on the last deer they were destined to find on their journey. They stopped several days to cure the venison, but the provision proved to be not nearly enough to see them through the mountains. They crossed the head waters of the Rio Grande and, winding through the hills, presently they reached waters flowing to the Pacific. A violent rain storm, the only really heavy rain they experienced in six months'

travel, soaked all the camp equipment—except the daguerreotype apparatus. The inevitable Carvalho with "careful precaution" always secured it against rain or snow. But he neglected to secure his own person, and he was so drenched that he gave himself up to gloomy and somewhat confused reflections:

> It is a happy thing for us that futurity is impenetrable, else my fond and fragile friends at home would endure more anguish than they do now, in their ignorance of the situation their husband and son is placed in.

The question arose of taking views from the top of a steep and rugged mountain. Colonel Fremont thought it would be impossible, as the ascent was too steep for the mules, and he regretted missing the fine panorama that might be obtained from such a vantage point. Carvalho said that with two men to carry his apparatus he would try. The colonel pointed out the immense difficulties. Carvalho insisted. Then Fremont said he would go himself with the daguerreotypist. Such condescension on the part of the leader touched Carvalho so deeply that he says:

> . . . it induced my unwavering perseverance in the exercise of my professional duties subsequently, when any other man would have hesitated and probably given up, and shrunk dismayed from the encounter.

Three hours' hard climbing brought them to the summit, and Carvalho was awed by the magnificence of the view. Plunged to his middle in snow, he made a panorama of the mountains, while Colonel Fremont took thermometer and barometer readings and examined the rocks. They descended to the camp without untoward incident. Colonel Fremont's action proved, says Carvalho, "that he would not allow his men or officers to encounter perils or dangers in which he did not participate." It may also have proved that the colonel wished to avoid a search for a tenderfoot daguerreotypist lost in the mountain snows.

As we have seen, Carvalho asserts that he continued to take views up to the day the baggage was abandoned, yet after this incident no further mention is made of photography. Dates are wanting in the story, but the party was now traveling in the depth of winter, their way through the mountains was deeply encumbered with snow, and the temperature was at times as low as 30 degrees below zero. The fast-flowing, ice-edged rivers were crossed with great difficulty. Provisions became very scarce and they had to kill their horses for food. The assistant engineer, Oliver Fuller, died from exhaustion. At last the baggage was cached in the snow and the men were mounted on the pack animals. After much suffering, early in February, 1854, the explorers finally reached the little town of Parowan in Southern Utah, and were very hospitably received by the Mormon inhabitants. Carvalho describes his pitiable condition, which was typical, he says, of all the others:

> I was mistaken for an Indian by the people of Parowan. My hair was long, and had not known a comb for a month, my face was unwashed, and ground in with the collected dirt of a similar period. Emaciated to a degree, my eyes sunken, and clothes all torn to tatters from hunting our animals through the brush. My hands were in a dreadful state; my fingers were frost-bitten, and split at every joint; and suffering at the same time from diarrhoea and symptoms of scurvy, which broke out on me at Salt Lake City afterwards.

After two weeks' rest at Parowan, Colonel Fremont and most of the others crossed the Sierra Nevada and continued on their way to California. But the daguerreotypist was not strong enough to go with them, and he journeyed to Salt Lake City in a wagon ("I had to be lifted in and out like a child") with a large company of Mormons on their way to "Conference." In his two months'

stay at Salt Lake City he received many kindnesses from the tall imposing president, Brigham Young, whose portrait he painted, as well as the portraits of some of the "Apostles." And here he grew so stout and able-bodied that his weight increased by 61 pounds.

On May 6, 1854, he set out for California with a party of 23 Mormon missionaries headed by Parley Pratt, the Mormon "Isaiah," and bound for the Sandwich Islands. This journey included the "perilous trip across the Great American Desert" featured in the title; but beyond the loss of a few horses nothing particular happened. Arriving at San Bernardino on June 9, he traveled by easy stages to San Francisco. How he got home from there he does not reveal. Here his story ceases, and the first official photographer fades out of history.

What happened to his hard won pictures is not definitely known. After mentioning their burial with the camp equipment, Carvalho says nothing more about them. Fremont, in his letter to the *National Intelligencer* dated the day after he reached Parowan, writes:

> Until within about 100 miles of this place we daguerreotyped the country over which we passed, but were forced to abandon all the heavy baggage to save the men and I shall not stop to send back for it. . . .

Yet somehow the plates were salvaged, for Allan Nevins states in his "Fremont: the West's Greatest Adventurer" that in the summer of 1854 Fremont was back in New York "working in the studio of the photographer Brady to assist in finishing the Daguerre plates taken by Carvalho." The plates, however, were never published. Professor Nevins says in a letter to the writer: "I believe he [Fremont] contemplated a careful history of the fifth expedition illustrated by the plates, but its ill success and other circumstances forbade this."

All Fremont made public on the expedition were the two newspaper letters already mentioned. The single illustration in Carvalho's book is not a reproduction of one of his own pictures, as might be expected, but a woodcut after a drawing signed "J. Dallas." It purports to show Fremont and Carvalho making astronomical observations. Of late years several searches have been made for the plates, but no trace of them has been found. Their certain fate is in doubt, but Daguerre pictures were so fragile that it is only too likely the plates of the undismayed Carvalho perished long years ago.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

ETHIOPIAN—THE OLDEST LANGUAGE

By Dr. JOHN P. HARRINGTON

SMITHSONIAN INSTITUTION

ETHIOPIAN is the oldest language in that it has departed the least in its forms from the original proto-Semitic. Even the Hebrew in which the Bible is written has gone a long road of development beyond even the modern Ethiopian. Hidden away in the African Alps, this old language has still survived, uncorrupted by the centuries.

Let us take, for instance, the name of the letter *a*. This letter in its capital form still preserves to-day very much of its original pattern, which was that of a crude figure of the head of an ox. The descending strokes at the bottom of capital *A* are the horns of the head of the ox. Ancient Egyptian has a very similar symbol. The natives of central Celebes have similar carvings of the head of the water buffalo on the beams of their houses. Now the name of this letter and of the ox is in the primitive Semitic, spoken 5000 B. C., *alf*. In ancient and modern Ethiopian the name *alf*, ox, is still on the tongue of the people. But in the Hebrew of the Bible it is already *aalef*, ox, the word having been distorted into two syllables and starting with a lengthened vowel.

So also with *b*, the second letter of the alphabet. The name of the letter means house, and the form of the letter is a picture of a house. The ancient proto-Semitic word for house was *bayt*. Ancient and modern Ethiopian also has *beet* or *byeet*, while the Hebrew, even the Hebrew of the Bible, has already changed the word to *beeth*, with *th* instead of *t*.

The writing of ancient and modern Ethiopian is as primitive and enticing as the language itself. Only here they have improved on the ancient Semitic alphabet, which had symbols for consonants only. If vowels were added in writing Hebrew, they were added outside the contour of the letter as separate dots and dashes, much as in some systems of shorthand. The overdotting of Hebrew with vowel points is well known. At the time the King James version of the Bible was being made, certain scholars and clergymen were in conference at Oxford University. One eminent scholar declared that a certain text on the table before him was letter perfect, or better said, "dot-perfect." They adjourned for lunch. When the clergymen returned an hour and a half later, an excessive dotting was discovered on the text. Great was the perplexity, until one of the members suddenly discovered and exclaimed: "A fly did it." Arabic writing is also full of dots. These dots and dashes are bothersome to make and often break off in printing, as is well known to printers. The inventive genius of the Ethiopians, who started with the same alphabet as the Hebrews, devised, however, the mere adding of ticks, loops, etc., connected with the consonant letters at their various corners, sides, tops, etc., to indicate the various vowels that follow. The Ethiopian system is as compact as it is legible, when one gets used to it, and does away with all the cluttering dots of Hebrew and Arabic. The Ethiopian letters are placed to read from left to right, just as in English, and a nice big colon is put at the end of every word, which keeps the words neatly apart in the manuscripts.

Ethiopia is the oldest Christian country, having been completely converted to Christianity at a date somewhere after 200 A. D. The Ethiopians were a thoroughly Christian country under a heavy priesthood at the time when Italy was persecuting Christians under the Roman emperors. The Ethiopian literature is from the earliest times rich, consisting of Bible translations, prayerbooks, liturgies and a wealth of documents of every description. Ancient Ethiopian was spoken down to 1600 A. D., when it broke up into the modern dialects. These modern dialects are still the most primitive Semitic languages, and the closest thing existing to ancient Egyptian, Egyptian's direct descendant, Coptic, having become extinct.

Ethiopian has been called from the first *lesawa* (tongue or language) *geghez* (of the free), that is, the language of the free. Why this name was applied has never been known, but it has been the common and only name of the language through all the ages. It shows that the Ethiopians have been a freedom-loving people throughout all the five thousand years of their unbroken existence as an independent nation.

The Ethiopian language is easy to pronounce and its words are easy to remember. It is sonorous. It is accented mostly on the next to the last syllable.

We shall give first some words in the old classical Ethiopian language to show how they stick with one. The Biblical word is in almost every instance similar but more corrupted. Doubling of vowels is here used to indicate long vowels.

Kitaab, book; *salaam,* health; *'aalam,* world, glory; *gabaar,* a workman; *naggaasii,* king, emperor; *mehraam,* temple; *manbar,* throne; *maslem,* Moslem; *barhaan,* light; *'aalamaawii,* earthly, worldly; *kawaanee,* being, existence; *wagr,* hill; *saittaan,* Satan; *kookab,* star; *Amlaak,* God; *manfas,* spirit; *qasiis,* priest; *xebest,* bread; *ana,* I; *nahhnu,* we; *ahhaduu,* one; *keleetuu,* two; *salastuu,* three; *arbaa'tuu,* four; *xamestuu,* five; *me'et,* a hundred; *elf,* a thousand.

Proto-Semitic is the hypothetical reconstructed language spoken 5000 B. C. and earlier. Its words are obtained by a comparative study of Hebrew, Syriac (a dialect of which was spoken by Jesus Christ), Phenician, Babylonian, Arabic and Ethiopian. The forms of old Ethiopian, of which we have just given sample words, are found often to coincide with those of Proto-Semitic!

We shall follow these examples with still more interesting titles of the Emperor and common words, which have appeared in the newspapers or which have connection with the present Ethiopian situation, in the modern official Amharic dialect of Ethiopia.

Hhay-leh Seh-lahs-syeh' Me-djem-meh-riah', Haile Selassie I. *Hhay-leh,* the Power or Virtue. *Seh-lahs-syeh',* of the Holy Trinity. *Me-djem-meh-riah',* the First.

Moh-ghah an-beh-sah' za-'em-ne-ged' Yeh-hu'-da, hath prevailed the lion of the tribe of Judah—ancient epithet of the King of Ethiopia. This motto means that Judah, the "lion's whelp" of the Old Testament' has prevailed over the other tribes. It refers to the Emperor's descent from King Solomon, of the tribe of Judah. It has been mistranslated as the "conquering lion of Judah."

Neh-guh-seh neh-gest', King of Kings; that is the Ethiopian way of saying "emperor." So called because the emperor is supposed to have kings under him. From *neh-guhs',* king. But the governors of the provinces are called *gehg.*

Zar-'ah Tseh-yohn', Bat-rah Tseh-yohn', the posterity of Zion, the staff of Zion, another ancient epithet of the Ethiopian emperor.

Eh-teh-gyeh', the Empress.

Ih-teh-yoh-peh-yah', Ethiopia — from a Greek word meaning sunburnt or dark-faced, referring to the Ethiopians; *It-yop-yah-wih',* an Ethiopian.

Ghad-wah', Aduwa, where the Ethiopians made a stand in 1896 to protect

their Holy City of Aksum from Italian annexation. *Ghad-wah'* means "the pass."

Ahd-dihs Ah-beh-bah', New Flower. The first word means new, the second means flower. This is the *meh-dih'-nah*, capital. The old capital was *En-toh-toh'*, meaning green place. The spelling "Ababa" is absolutely wrong. The middle vowel is e.

Mah-zer-yah' Tsah-nah', Lake Tsana, at the source of the *Ab-bay'*, Blue Nile. This Ethiopian lake covers 2,980 square kilometers and is the center of the irrigation project for increasing the irrigated lands of Egypt.

Ahm-lahk', God; *Ih-yeh-suhs' Kres-tos'*, Jesus Christ; *Kres-tih-yahn'*, Christian; *Kres-ten-nah'*, Christianity.

Eh-hhih-geh', head of the Ethiopian Church; *Ieh-pis-qoh-pos'*, bishop; *Qyehs*, priest; *Byeht kres-tih-yan'*, church, literally Christian house.

Weyn, wine of sacrament; *meh-lahs' geh-ghehz'*, the language of the free, name of the ancient Ethiopian tongue used in the church.

Ih-tah-leh-yah', Italy; *Ih-tah-leh-yan'*, Italian; *En-gliz'*, English.

Leb-yah', Libya, Italian colony west of Egypt one and one half times as large as Egypt; *Gebts*, Egypt; *Qey Bah-hher'*, the Red Sea; *Bah-hher' Rom*, the Mediterranean (literally the Roman) Sea! *Mes-noh'*, the Canal; *Suh-wes'*, Suez; *Port Sayd*, Port Said.

Tor, spear; *yeh-feh-reh-seh-nyoch'*, cavalry, literally horsemen spear; *yeh-medf tor*, artillery, literally cannon spear; *yahz-mach tor*, regiment, literally soldier spear; *yeh-tor mer-keb'*, war vessel, literally boat spear; *bah-ruhd'*, powder; *yeh-bah-ruhd byeht*, powder horn or receptacle, literally powder's house; *yeh-bah-buhr'*, airplane pilot; *ras*, a general, literally a head—meant head in old Hebrew; *weh-tad-der'*, a soldier, fighter; *seyf*, sword; *sam-djah'*, bayonet; *medf*, cannon; *erd*, fortification; *guhd-gwahd'*, the trenches—sounds like "good God!"; *ah-dah-gah' mew-dek'*, an attack; *del*, victory; *neft*, rifle—our word naptha pressed into this use.

Yeh-'irq mah-gah-nay-nyat', the peace meeting (the League of Nations meeting); *as-tah-rah-qih'*, the peacemakers (of the League); *ah-beyt'*, justice.

CHANGING VARNISHES

By Dr. HENRY J. WING

E. I. DU PONT DE NEMOURS AND COMPANY, PARLIN, N. J.

Four thousand or more years separate the time of the varnishing of the mummy cases in the Metropolitan Museum in New York and the time at which the varnish was put on the butterfly table which you may carefully cherish because it belonged to your great-grandmother. One hundred years may separate the time of finishing of this table and that of your own dining room furniture. However, there may be far greater differences in the last two finishes than between the first two. True, the first varnish was probably applied hot with a paddle, since the art of adding thinners to the varnish was not known, but in general the type of material was much the same as that produced through the ensuing years.

But many of the varnishes and lacquers to-day are only distantly related to those produced in our grandfather's or even our father's time. Furniture lacquers are used which contain no "natural" product. That is, the whole film may be made of products produced synthetically. Others may contain some oils which have simply been treated but which contain new resins in place of the

natural gums which were used in the varnishes of yesterday.

These changes have brought about harder, smoother finishes and ones which resist rubbing, scratching and water or other liquids to a much greater degree than did their predecessors. They also have the advantage that the manufacturer can finish more pieces in a given time, for many of them dry rapidly, and so reduce the cost, which is reflected in the price to the consumer.

Other types of finishes have been undergoing change too. Not many years ago the worth of a paint could be readily shown by indicating that the oil used was entirely linseed oil. Modern study has shown that other oils have a very definite place and, in fact, may give desirable properties which otherwise could not be obtained in the paint, varnish or enamel. Increased speed of drying or harder more water repellent films may be brought about by the proper use of some of the newer types of oils.

"Oils for the lamps of China" may be an important industry, but within the last few years China has been shipping large quantities of two other types of oil to the rest of the world. These oils from the view-point of the paint and varnish maker are of the highest importance. One of them, chinawood oil or tung oil, has been produced for years, but it has been only within perhaps the last twenty-five years that it has assumed an important place in the paint industry. Its use depended upon the discovery of the proper method of treatment in order that it might be used as a paint or varnish vehicle. When this method was once worked out, great improvement in the water resistance of varnishes and of paints and enamels made from them was brought about. Now it has become so important that large areas in Louisiana and other southern states have been set out in tung tree groves. This domestic oil is very slowly coming on the market, the result of careful experimentation as to proper conditions for the growth and cultivation of the trees.

China also exports large quantities of another oil, most of which is obtained from the northern part or from Manchuria. This is obtained from soya beans, the same kind of beans which were so widely recommended in some sections of our Middle West last year, after the drought had broken, for use as a quick-growing forage in order to partly replace the crops which had been destroyed. This oil also was one which only awaited the discovery of proper methods of processing to make it a valuable paint ingredient. Its use has been widely publicized by the producer of one of our popular cars, who has shown that the beans can be grown and the oil extracted successfully in this country. In fact, we now produce more than our requirements. However, this was not accomplished without long and careful investigation of the properties of the oil and the best methods for treating it in order to make it a useful ingredient for paint manufacture.

Paints, varnishes and enamels have all been mentioned. However, the liquid used in each may be quite similar. A clear or unpigmented coating material, if made principally from oils or oils and resins, is a varnish. This same varnish may be used in paints or enamels, although many modern paints contain but little varnish, the vehicle being an oil treated to cause proper drying. The main distinction between a paint and an enamel is that an enamel is glossier than a paint. This glossiness, if the same vehicle is used, is due in part to the fact that the pigment particles in the enamel are much smaller than those in the paint. In general, decreasing the size of the pigment particles increases the glossiness of the finished product.

For years most automobiles were finished with oil type varnish enamels. A few in the lowest price range received a baked black enamel, but for the most

part the speed of motor car production had to be fitted to the drying time of the enamels used. Some improvements were made. New types of driers were introduced into the varnish, which speeded up the finishing process, but the increased speed of drying usually meant a decided decrease in the wearing qualities of the finish on the car.

For many years lacquers were used which depended on the evaporation of solvents for producing the finished film. Nitrocellulose was used as the film-forming material in some of these, but it had the disadvantage that in order to make solutions thin enough to be applied properly, it was possible to use only very little solid nitrocellulose in the lacquer. A freely-flowing lacquer containing much more than 6 per cent. nitrocellulose could not be made. Even this lacquer was the product of long and painstaking research, for it had developed with the making of gun cotton, photographic films and celluloid.

About 1925 an entirely new aspect of the protective coating field was opened up purely on the basis of research. Methods were discovered by which nitrocellulose could be made such that solutions containing as high as 15 per cent. of this solid were more fluid than the old 6 per cent. lacquers.

In the development of these lacquers we find an example of the interdependence between various chemical processes. During the world war the allies, and later our forces, needed large quantities of acetone to make "dope" or lacquer for airplane wings. Chemists in this country quickly adopted for large-scale production a process whereby certain types of bacteria acting on corn mash produced acetone and the little known butyl alcohol, a relative of grain alcohol but having a larger molecule. This process was very successful, so successful, in fact, that enormous tanks of by-product butyl alcohol were soon accumulated. The close of the war still found no extensive use for this material, but ten years later this same process, based on the bacterial action, became again of great importance. Now the two products found their rôles reversed. Butyl alcohol had become the important product and acetone the by-product.

This change of state was due to the rapid development of the nitrocellulose lacquer industry. This new industry used more and more solvents, and one of the most important solvents was made from butyl alcohol. Butyl alcohol and its compounds are still important lacquer solvents, but the rise of the lacquer industry has stimulated research and brought about the development of many others.

This same demand has been reflected in the development of processes for making solvents from the by-products of gasoline manufacture. Here a curious interlocking of processes has appeared. Our modern high compression automobile motors demand a gasoline of low knocking properties. One way of producing this gasoline is to heat heavy petroleum fractions to high temperatures. Under these conditions lighter molecules are formed which in part go to make gasoline. At the same time large quantities of unsaturated gases are produced. Within the last year or two it has been found possible to so treat part of these gases that alcohols and other organic solvents of great importance to the lacquer industry may be produced. Many organic compounds which were laboratory curiosities ten years ago are now made in carload lots. They find their use in the production of finishes for the beautiful motor cars of to-day.

Modern motor cars are for the most part finished in either of two ways. One large manufacturer uses a type of enamel carrying newly invented resins made by treating oils with phthalicanhydride. This latter chemical, a curiosity but a few years ago, is now produced by the carload.

These finishes are dried by low temperature baking and have the advantage that they require but little polishing for their completion. They have the disadvantage that the refinisher finds them more difficult to repair after minor accidents but that problem has now been solved satisfactorily.

Larger numbers of cars are finished with nitrocellulose enamels. The introduction of these finishes resulted in brighter, glossier cars, even in the lowest price field, and in lowering to some extent the cost of the cars. This economy was accomplished by the great decrease in the time required to finish a car. Before 1925 the finest finishes could be produced only by waiting for at least a day between coats. Now the complete finishing operation can be done in less than a day. This means a great economy in time, with the consequent decrease in costs.

Moreover, these lacquer finishes are better than the varnish finishes of former years, for they are harder and so will take a high polish, and they wear better, for they resist scratching and abrasion to a greater extent than the older type of finish.

WHEN THE DUCKS FLY SOUTH

By Dr. W. B. BELL

CHIEF, DIVISION OF WILDLIFE RESEARCH, U. S. BIOLOGICAL SURVEY

When the ducks fly south each year they carry with them the message of the mysterious rhythm of the seasons. Each southward flight in the fall recalls to mind the thought of other flights in the past, and this thought leads to the anticipation of recurring flights in the future.

The power of this phenomenon of migratory birds to give the onlooker a quickened sense of the enduring rhythms of nature is one of those intangible, esthetic benefits that come with the presence of wildlife—invaluable, we know, and yet valued in such a way that none of us can state its worth. It affects not only the hunter to whom the flight of the ducks means the return of his sport—it can thrill also the non-hunter; in fact, every one who can escape to the outdoors with an awareness of the happenings about him.

And, as our civilization becomes more complex, as life in the city becomes more nerve-racking, we shall be seeking the outdoors in increasing numbers—as sportsmen, as hikers, as tourists. We, and those who come after us, will be appreciating more highly than ever the flights of the ducks. It is for this reason that the conservation of our waterfowl is such an important public problem—a problem in the discussion of which a speaker addresses fellow citizens, not any particular group alone, but all who are a part of the civilization in which we live.

When the ducks fly south most of them cross an international boundary. The public problem of their conservation is, therefore, in this country, a concern of the Federal Government. Nearly twenty years ago the United States and Great Britain agreed by treaty to protect the migratory birds in Canada and this country. The act of Congress that gave effect to this treaty directed the Secretary of Agriculture to determine from time to time "when, to what extent, if at all, and by what means" the hunting of these birds might be allowed, and to adopt suitable regulations to govern hunting. The act charged the secretary with "having due regard to the zones of temperature, and to the distribution, abundance, economic value, breeding habits, and times and lines of migratory flight." Congress thus required a scientific basis

for the regulation of wildfowling, and this basis has been continuously provided by the Bureau of Biological Survey. Ever since the beginning of federal protection of this resource, the Survey has been observing the waterfowl conditions on this continent and making recommendations for its conservation.

Throughout all the years of these observations there has been one fact that has almost constantly faced the Survey's investigators. That fact is this: The ducks are decreasing in numbers. This decrease is not a new thing in our day, but we have reached the time when the waterfowl populations can no longer stand continued decrease. As far as some species are concerned, we are fast approaching the minimum that can be reached without inevitable extinction.

Thirty-five years ago, in January, 1900, a writer spent a few days on Currituck Sound hunting canvasbacks. On one day when there was no shooting he observed the large numbers of birds during freezing weather. "Much of the day," he said (and I am quoting), "was spent on top of the club house, studying their inconceivable numbers. All around the horizon except on the landward side—that is to say, for 270 degrees of the circle—birds were seen in countless numbers. Turning the glasses slowly along the horizon from northwest to north, east, south, and southwest, there was no moment at which clouds of flying fowl could not be seen in the field of sight." That is the end of that quotation, but a little farther on in his account, the author says (and I am again quoting), "Looking with the glasses over the smooth ice away to the northward, we could see flying over the ice, or resting on it, fowl as far as the eye could reach."

Reports from the same area last year make only a pitiful comparison with this account at the beginning of this century. Yet even in 1900 the writer whom I have already quoted was alarmed over the decrease in the waterfowl. He devoted the last 35 pages of his book to a chapter entitled "The Decrease of Wildfowl." It is more than interesting to note that he attributed the decline to two main causes, and these causes are precisely the same as those that appear to us to-day. He wrote (and I quote), "Two prime causes exist for the diminution of wildfowl. These are over-shooting, and the settling up of the country."

To-day we are in a startling situation. Thirty-five years after such a clear warning, the birds continue to decrease—and for the same reasons that were pointed out a generation ago! The forces of conservation move slowly among a people as uninformed and unconcerned as we Americans have been in the past. Yet these forces do move, and it is the recent acceleration of this movement that brings the matter to the attention of this nation-wide radio audience. To-day the people of the United States are trying to stop the decrease in waterfowl. Through the U. S. Biological Survey the Federal Government is carrying out a national program of waterfowl restoration. This program is based on the facts gathered by the Survey's scientists.

Two causes for the waterfowl decrease—two aspects of the restoration program. If one cause is the "settling up of the country," one remedy will be restoring to the birds areas that have been unwisely devoted to agriculture. And so, the Biological Survey, of the U. S. Department of Agriculture, is establishing refuges—places where the birds may breed or winter in safety. In time the Biological Survey hopes to give back to the birds some 3,000,000 acres. These areas must be selected, and in most cases they must be developed. To be done right the selection and the development activities must be based on scientific facts. Well-qualified naturalists are thus employed to select areas that are biologically suitable and to recommend improvement measures. This is science service for the refuge program.

The other aspect of the restoration program deals with overshooting as a cause of the decline in our waterfowl populations. Now, the remedy for this would on first glance seem apparent. If shooting is threatening our birds, prohibiting this practice would seem to be the quick and easy method of stopping the decrease. But the question arises: "How shall we stop the overshooting?" One answer is: "Make a federal regulation to close the season," but it is an answer that seems to underestimate practical difficulties. More than a million people are vitally concerned with the waterfowl hunting regulations, and when I say vitally concerned with them I mean that they are going to protest vigorously against any restriction that seems unjustified. In a democracy such protests necessarily have an effect on government. That is a very real consideration to administrators of federal regulations. Furthermore, under present conditions, the enforcement of the federal game laws is dependent to a great extent on the cooperation of state agencies and of sportsmen. Thus the whole problem of regulating shooting becomes one essentially of education with an always current need for up-to-date information.

There is another reason for our need for up-to-date information each year. Of the two alternatives—prohibiting hunting or allowing it with severe restrictions—the wiser seems to be the one that is less drastic. Yet if hunting is to be allowed we must be certain that it does not mean a continuance of overshooting. We must be certain that our annual loss from all causes—including hunting—is less than our annual increase from breeding. This policy makes it necessary to keep books on our ducks.

The need for basic data on the status of waterfowl is a need for the services of scientists. These scientists must be competent naturalists whose reports may be used effectively in informing the public of the actual waterfowl conditions. In other words, they must provide the factual basis for the educational work in the national conservation program. More important still they must provide the data on which the hunting regulations are based.

The Biological Survey's personnel includes such scientists, and they have been conducting the most extensive field studies of waterfowl ever undertaken. As the birds move south in the fall to the swamps of Louisiana, to the lagoons of Texas, to the lakes of Florida, even to tropical Yucatan, the Biological Survey scientists follow them. After the hunting season the survey men continue to check up on the waterfowl populations and conditions. The week starting Monday, January 21, 1935, was, for instance, selected for a checkup on the waterfowl population on the winter resting and feeding areas by Biological Survey scientists—the most comprehensive study and carefully planned survey that has ever been undertaken for this purpose. A selected group of about 300 field agents attempted a simultaneous estimate on the concentration areas. The most severe storm of the winter, covering nearly the entire country, set in on the day the inventory was to start. Yet the men assigned to the job did an excellent piece of work; and, while the results obtained were inadequate, the methods and experience gained point to more efficient results in the future. Confronted by snow-blocked highways and suddenly frozen watercourses, the men succeeded in one way or another in getting to a large number of waterfowl concentration areas. One agent was actually marooned for nearly a week on a small island in Chesapeake Bay, where he received emergency food supplies dropped by an airplane, and was finally rescued by a Coast Guard cutter that was able to break through the ice. The reports of the agents were assembled by the eight regional directors of the Bio-

logical Survey, who then made corrections to allow for the good duck areas it had been impossible for agents to reach. And after the winter was over —when the birds had again flown north —the Biological Survey naturalists observed the conditions on the breeding grounds.

It should be borne in mind constantly that the entire breeding range of all species of migratory waterfowl covers a vast area. Broadly speaking, it includes the entire continental land mass north of the 40th parallel of latitude. This crosses the middle of the United States and forms the northern boundary of Kansas. A considerable number of ducks also nest even south of that line. Obviously, no individual worker or limited group of specialists can cover so vast an area in one season. There are, in fact, not enough biologists in the entire United States and Canada to do the job, even if they were all working on it. It is possible, however, to get good results by the "sampling" method, and that is what the Biological Survey has done.

The summer work is made to determine the probable ratio of increase from nesting. It should not be confused with the census or winter inventory. This inventory is made on the southern waters, in mid-winter, when the birds are rafting on the open water. A summer count when the birds are hidden by heavy vegetation has proved too inadequate to be of any value.

Five field parties were assigned this year to the Canadian breeding grounds —one in British Columbia; one in southern Alberta and Saskatchewan; and one in northern Alberta and Mackenzie; one in Manitoba and southeastern Saskatchewan; and one in the Maritime provinces of New Brunswick and Nova Scotia. The leaders of all five of these parties had previous experience in the regions assigned to them, and in most cases they operated in the same territories during the season of 1934.

The results of these scientifically conducted investigations indicate that the waterfowl have not yet by any means emerged from the crisis. They do show, however, that conditions are slightly improved over last year, and that the net annual increase required for restoration can be obtained with a short open season with severe restrictions.

Accordingly, the season last fall consisted of only thirty days in each of two zones—in northern states, from October 21 to November 19, and in southern states, from November 20 to December 19. Legal hunting of waterfowl on these days did not start until 7 A. M., and closed at 4 P. M. No live decoys could be used. Shooting over baited waters or land was taboo, too, as was also the open water shooting that has been so destructive to diving ducks. Careful studies by the Biological Survey had shown that all these practices make heavy kills far easier for the hunter.

When the ducks again fly south, we thus hope to see larger numbers than last fall, and so also the next year after that, and the next, and the next. Our hope is a reasonable one. With the hearty cooperation of conservation agencies, state game departments and local sportsmen; with regulations formed on a scientific basis; and with policies that are formulated with careful regard for their practicability, the program can be realized. It does require cooperation on the part of some who might wish conditions otherwise. It does require the awakened interest of the non-hunting public as well as the sportsmen. But, withal, the prospects are encouraging, and we are working earnestly to accomplish the restoration of the waterfowl—an immensely valuable natural resource. It means money for many, but it means sport, recreation and esthetic delight for countless others also. I thank you for your interest, and I wish for each of you many, many autumns in the future to behold the inspiring spectacle that is in the skies when the ducks fly south.

THE WHALE SHARK OFF HAVANA

By Dr. E. W. GUDGER

ASSOCIATE CURATOR OF FISHES, AMERICAN MUSEUM OF NATURAL HISTORY

I HAVE been pursuing the whale shark for twenty-three years, yet, from the perusal of a vast literature together with the letters of a far-flung correspondence, I have been able to enumerate, as of January 1, 1935, but seventy-six definite records. Since then I have recorded a sixth specimen from Acapulco, Mexico—the seventy-seventh known fish. The seventy-eighth fish was recently recorded by C. S. Brimley from a specimen which came ashore at the mouth of the Cape Fear River, N. C., in June, 1934. And now comes the seventy-ninth record of the largest and most strangely marked and colored shark, *Rhineodon typus*, that swims the seas. So the capture of a new specimen and the taking of a good photograph of it are of the order of an event, ichthyologically speaking.

Two other whale sharks have been captured off Havana and have been recorded by Dr. W. H. Hoffmann and myself. And now to these, I add a third.

The first Havana specimen was taken on November 20, 1927, at Jaimanitas, a fishing village about five miles west of the mouth of Havana Harbor. In round numbers this fish was thirty-two feet in length and eighteen in girth. Its body was about six feet in depth and the "small" of the tail was so great that a grown man could barely encircle it with his arms. The heart weighed forty-three pounds, the liver 900, and the total weight was estimated at nine tons. In the published record (1928) four figures of the fish were reproduced.

The second Havana whale shark was taken on March 10, 1930, at Cojimar Bay, about five miles east of the mouth of Havana Harbor. This giant was thirty-four feet long and its weight was also estimated at nine tons. Dr. Hoffmann and I put this specimen on record in 1930 but without reproducing the photograph. This was remedied in 1931, when we published a third article with all the photographs of both specimens.

And now I have the pleasure of putting on record the third Havana *Rhineodon*—captured on April 12, 1934. To preserve symmetry in the geography of these captures, this last fish allowed itself to be taken in the mouth of Havana Harbor, opposite Morro Castle. It was harpooned by Captain Tom Gifford, whom I made known as the captor of a *Rhineodon* off Miami, in January, 1932.

Captain Gifford had charge of a private yacht, with owner and party out fishing for marlin swordfish. One of the party was fighting a marlin when the whale shark came swimming fearlessly up toward the stern of the yacht. When almost at the stern, the harpoon was thrown. The great shark then turned and sounded. Having a heavy line on the harpoon, the fish was presently brought to the surface, tied to the stern of the yacht and towed into the harbor. Here it was swung up on the side of the yacht and dispatched with a rifle (15 shots being required). Like all the other whale sharks for which I have records, this one put up no fight, and in fact did practically nothing but try to swim away.

This excellent photograph of this great fish shows it swung up alongside the yacht. On its body note the parallel ridges—one dorsal and three lateral (on each side). Note also the vertical bars (in some cases made of confluent spots), and in the rectangles thus formed note the large white or yellow spots. This rectangular arrangement of bars and spots has led the Cubans to call our fish *pez dama* (checkerboard fish).

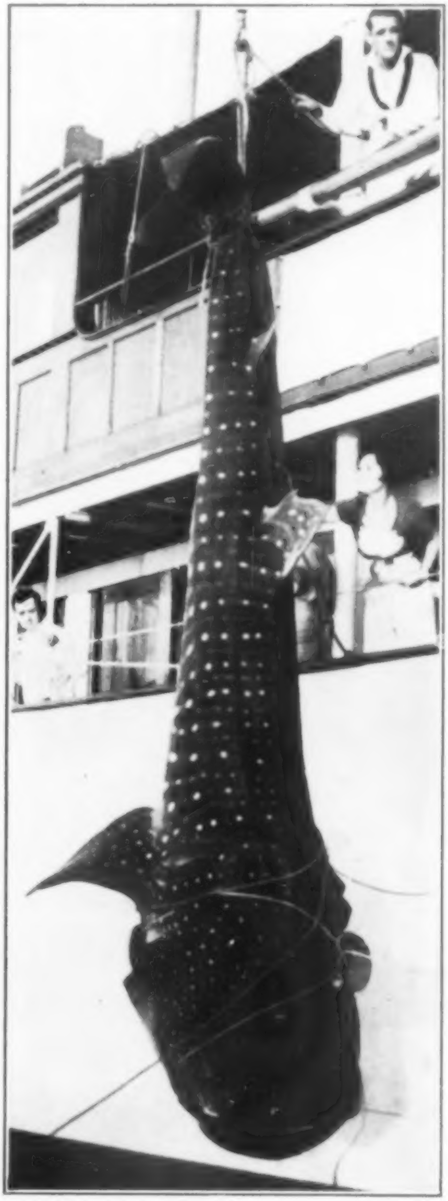
Noteworthy also are the huge gill-slits—exceeded in length only by those of the basking shark of colder waters, which

grows to about the same size—the huge broad head, spotted all over, and the enormous terminal mouth. Most sharks have the mouth under the head, hence the fiction that a shark must turn on its back to bite, and none (not even the basking shark) has a mouth so large as *Rhineodon*. With the jaws wide open this fish could take a boy into its mouth cavity.

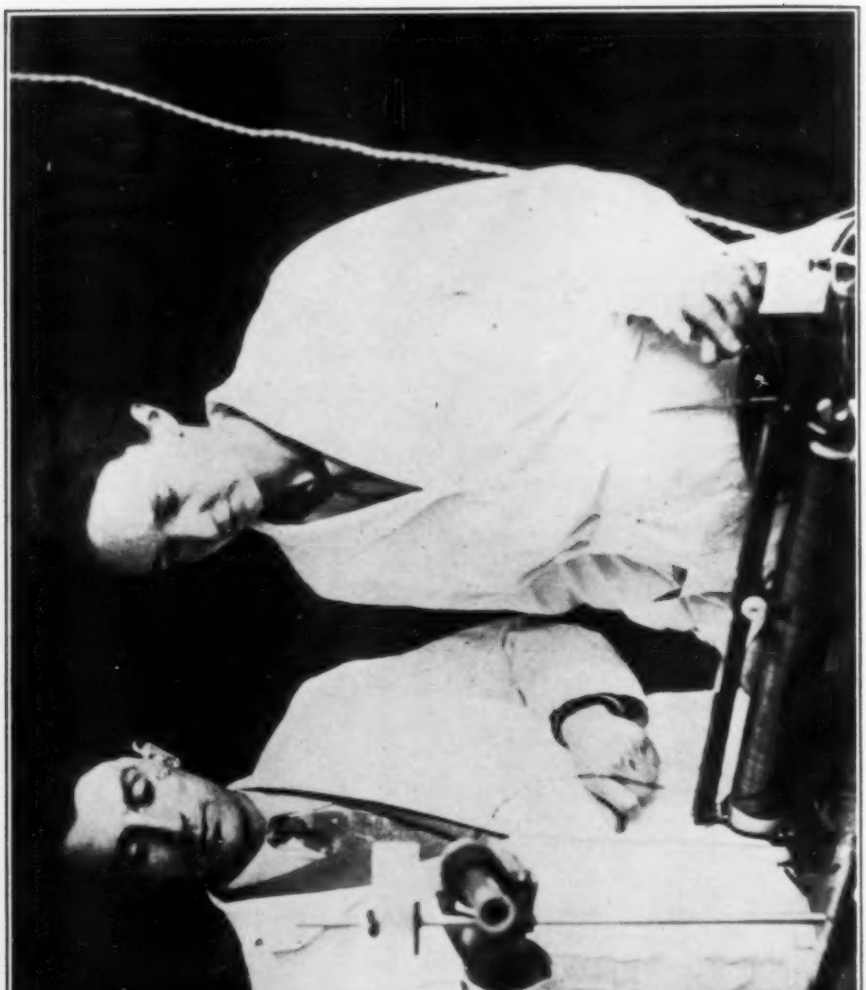
This specimen was twenty feet, ten inches in length and its weight was estimated at 5,000 pounds. Since whale sharks have been measured up to forty-five feet and estimated up to sixty by scientific men and by whalers used to making such estimates, this one must be reckoned a young and a comparatively small specimen. The relatively small size of this particular fish was a fortunate matter, since it made it possible to swing up the fish alongside the yacht and to make the beautiful photograph shown in the figure.

This photograph, showing so clearly the extraordinary markings and coloration of *Rhineodon*, is a great addition to the collection of photographs of this shark in the American Museum—the largest aggregation of such photographs in the world. In this collection there is but one other picture which even rivals this one. For this latest photograph, I am indebted to the courtesy of Mr. Al Pflueger, naturalist and taxidermist of Miami, Florida.

This is the eighth whale shark taken in the Straits of Florida. The first record goes back to 1902, when an eighteen-foot specimen came ashore at Ormond Beach, Fla. The record will surely grow, since reports have for a number of years been coming in to me of the whale sharks seen off Havana, and particularly in the waters between Miami and the Bahama Islands. These reports are probably true, since the fish is becoming pretty well known—especially to the fishing boat captains at Miami.



NOTE: Persons interested in the history and distribution of the whale shark throughout the warm waters of the world are referred to my article in the Proceedings of the Zoological Society of London for 1934 (1935, pp. 853–893, 2 pls. and 2 maps). This contains a complete bibliography of *Rhineodon* to January 1, 1935.



PROFESSOR FREDERICK JOLIOT AND MME. IRENE CURIE JOLIOT

THE PROGRESS OF SCIENCE

AWARD OF THE NOBEL PRIZE IN PHYSICS TO JAMES CHADWICK AND IN CHEMISTRY TO FREDERICK AND IRENE CURIE JOLIOT

So closely linked have been the discoveries of the neutron and of artificial radioactivity that it is fortunate that there are two closely related Nobel prizes, one of which (physics) could be awarded this year to Professor James Chadwick for the exceedingly important discovery of the neutron and the other of which (chemistry) could go to the Joliots for the no less significant discovery of artificial radioactivity.

Never have two Nobel prizes been more richly merited, for the two discoveries together have drawn the veil from the holy of holies of the physical world — the heart, or nucleus, of the atom—and revealed the activities going on therein—activities which have determined and are still determining the fates, not of peoples and kingdoms, but of worlds and galaxies. Through these discoveries we can now begin to see how some of the heavier atoms are being built up under our eyes out of hydrogen. Also with their aid we have already produced more than seventy definite cases of the "transmutation of the elements."

Professor James Chadwick has been one of the most able and most fruitful workers in the Cavendish laboratory for fully twenty years and has just this year left that post to accept the professorship of physics in the University of Liverpool. His name has been associated with many important problems in the field of radioactivity and atomic physics. One of the most difficult and most important of these consisted in the accurate determination in 1920 of the charge on the nuclei of several atoms from the scattering of alpha particles by these nuclei. It certainly was a triumph of experimental skill when the charge on the nuclei of the atoms of lead, silver and cop-

PROFESSOR JAMES CHADWICK

per came out of such scattering measurements by Chadwick as 77.4, 46.3 and 29.3 in place of 78, 47 and 29, the whole number values given them in the atomic number series. With this kind of a record the world of physics was not surprised by the skill and insight shown in the discovery of the neutron. Although Bothe and Becker in Germany and the Joliots in Paris had prepared the way for him, it was Chadwick who marshalled the old evidence for the existence of the neutron, then predicted new results on the assumption of its existence and checked the prediction by unambiguous experimental proof.

It is surely a significant circumstance that the babe who was being conceived and born when radium was being discovered by the joint work of that babe's father and mother should, thirty-eight years later, working in her turn with her own husband, F. Joliot, follow the lead of her parents in making a great discovery in the field of radioactivity. Until this work was done every one believed that the phenomenon of radioactivity was completely beyond the control of man, yet here it was produced *artificially*, and since then it has been produced in several different ways and with scores of different working substances. What may we not expect from the third generation of Curies which is already on the way?

Also without the preceding work of Bothe and Becker in Germany and that of the two Joliots in Paris, Chadwick could scarcely have been in position to get in Cambridge the proof of the existence of the neutron. Big results then have followed from these discoveries which are being honored by this year's Nobel prizes.

ROBERT A. MILLIKAN

THE ANNUAL MEETING OF THE AMERICAN ASSOCIATION

How different is the world to-day from what it was when, fifty-seven years ago, the association held its first St. Louis meeting. At that time applied science was in its infancy. Indeed, all forms of science were in a more or less elementary state, judged by the standards of to-day.

Between the time of the first and the present fourth St. Louis meetings science has so modified our mode of life and way of living and has provided us with so very many things we now regard as indispensable necessities that it is difficult to imagine ourselves back in those earlier days.

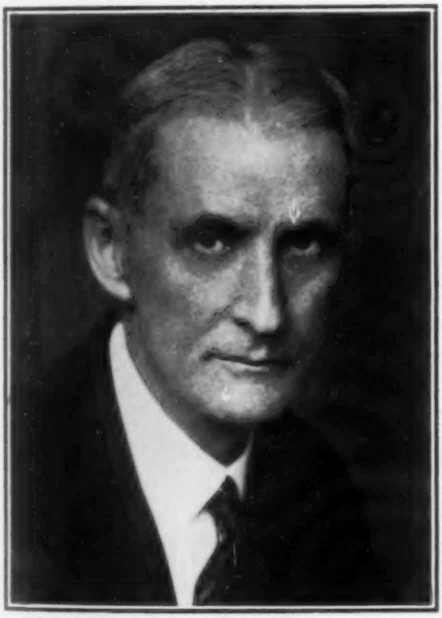
The transformation that has taken place during the past threescore of years has in no small degree been stimulated by the meetings of the association. These annual meetings serve a double purpose.

In the first place, they serve to bring together the scientific workers of the country. Through the presentation of technical addresses and papers and by discussions the latest advances in all lines of science are made generally known. The students in all lines of science are able to exchange ideas and information, and by so doing each is able to obtain a clearer insight into what is being done in his or her field of special interest—astronomy, zoology, physics, chemistry, the social sciences or whatever it may be—than would be possible merely by reading printed memoirs.

And besides all this the research workers, most of whom are connected with universities, colleges and schools or museums or other institutions throughout the country, are able to meet each other and to form lasting friendships which in later years serve to stimulate and to increase the interest in the search for scientific truth. For the younger men especially this is a very great advantage. They are able at these meetings to meet the older men who are the recognized leaders in their special lines and from this personal contact to gain increased

DR. T. H. HILDEBRANDT
PROFESSOR OF MATHEMATICS, UNIVERSITY OF MICHIGAN; CHAIRMAN OF THE SECTION OF MATHEMATICS.

DR. MOSES GOMBERG
PROFESSOR OF CHEMISTRY, UNIVERSITY OF MICHIGAN; CHAIRMAN OF THE SECTION OF CHEMISTRY.



DR. HERBERT R. MORGAN
ASTRONOMER, UNITED STATES NAVAL OBSERVATORY; CHAIRMAN OF THE SECTION OF ASTRONOMY.

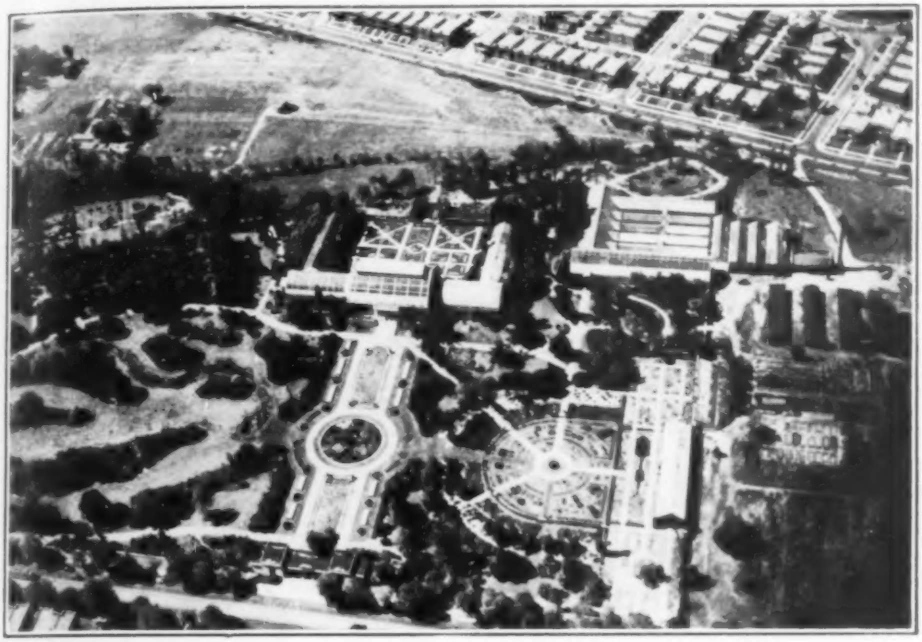
DR. WALTER E. McCOURT
PROFESSOR OF GEOLOGY, WASHINGTON UNIVERSITY; CHAIRMAN OF THE SECTION OF GEOLOGY AND GEOGRAPHY.

DR. OSCAR RIDDLE
STATION FOR EXPERIMENTAL EVOLUTION, CARNEGIE INSTITUTION; CHAIRMAN OF THE SECTION OF THE ZOOLOGICAL SCIENCES.

NELS C. NELSON
CURATOR OF PREHISTORIC ARCHEOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY; CHAIRMAN FOR ANTHROPOLOGY.

THE LATE DR. JOSEPH PETERSON
AT THE TIME OF HIS DEATH PROFESSOR OF PSYCHOLOGY, GEORGE PEABODY COLLEGE FOR TEACHERS; CHAIRMAN FOR PSYCHOLOGY.

SHELBY M. HARRISON
GENERAL DIRECTOR OF THE RUSSELL SAGE FOUNDATION; CHAIRMAN FOR SOCIAL AND ECONOMIC SCIENCES.



AERIAL VIEW OF THE MISSOURI BOTANICAL GARDEN

confidence in the value of their own work and, more important still, to learn how their special work fits into the structure of science as a whole, and the relation of science as a whole to the broader phases of human activities and of human thought.

This aspect of the meetings is of interest chiefly to the members of the association and their guests, though every one who is interested in any of the various branches of science may attend the meetings.

In the second place, the association realizes its responsibilities to the general public. The ultimate aim of all scientific work is the betterment of human welfare, both in its material and in its non-material aspects. Every established scientific fact has a definite bearing on some phase or other of human activity or of human thought. Not so very long ago many of the principles involved in the operation of the radio were regarded as merely curious phenomena and were unknown except in the laboratories of the physicists. The curious isolated facts of one decade may in the next become correlated with other facts into basic principles. In science no one can foretell what is going to happen.

But science can not advance unless it has the support of the people as a whole. Popular support is based upon popular interest, which leads to confidence in the workers and in the work produced.

So in connection with the meetings of the association there are given a number of popular talks which treat of scientific subjects in a broad way and in language intelligible to all. These talks show how the data upon which scientific generalizations are based are accumulated and correlated, and by this correlation are made useful.

Such talks deal with the exploration of unknown or of little known portions of the earth's surface, with the exploration of unknown or little known portions of, or objects in, the skies, or with the ex-

DR. GEORGE SARTON

LECTURER ON THE HISTORY OF SCIENCE, HARVARD UNIVERSITY; CHAIRMAN FOR THE HISTORICAL AND PHILOLOGICAL SCIENCES.

DR. HARVEY N. DAVIS

PRESIDENT OF THE STEVENS INSTITUTE OF TECHNOLOGY; CHAIRMAN OF THE SECTION OF ENGINEERING.

DR. STANHOPE BAYNE-JONES

PROFESSOR OF BACTERIOLOGY, SCHOOL OF MEDICINE, YALE UNIVERSITY; CHAIRMAN OF THE SECTION OF THE MEDICAL SCIENCES.

DR. H. K. HAYES

PROFESSOR OF AGRONOMY AND PLANT GENETICS, UNIVERSITY OF MINNESOTA; CHAIRMAN FOR AGRICULTURE.

ploration of the borderlands of physics, chemistry or biology. They also deal with the more concrete problem of just how science affects us in our daily lives. In these talks the broader aspects of the technical advances such as those described in the more formal papers are presented in simple language that can be understood by every one.

Talks and addresses, however, are not the only means by which the advances of science are brought to the attention of the members and the guests at the association's meetings. For some years now the annual science exhibition has been an increasingly important function of these gatherings. In this exhibition may be seen the latest and most improved apparatus used in scientific research in very many different lines. Demonstrations vividly portray many of the more recent truths discovered, and the application of new scientific methods in the arts, industries and commerce. And besides all this, there are shown the latest and most authoritative books on almost every scientific subject.

The meetings of the association year by year form a continuing picture of the onward march of science, showing what has been accomplished, and at the same time pointing the way to further and more efficient exploration of the infinite expanse of the still unknown.

The background of this picture, the increasing interest in, and support of, science in this country, is furnished by the progressive increase in the numbers of the association's members. At the time of the first St. Louis meeting, in August, 1878, there were 618 members. By the time of the second St. Louis meeting, in December, 1903, to January, 1904, the number had risen to 4,127. The membership at the time of the third St. Louis meeting, in December, 1919, to January, 1920, had risen to about 11,000. At the present time it is about 18,000.

DR. F. B. KNIGHT

PROFESSOR OF PSYCHOLOGY, STATE UNIVERSITY OF IOWA; CHAIRMAN OF THE SECTION OF EDUCATION.

The growth of science and the scientific spirit in this country has been as steady as it has been phenomenal. In view of the past we have every reason to be confident of the future.

AUSTIN H. CLARK

EXPLORING THE STRATOSPHERE

ON Armistice Day, 1935, Captain A. W. Stevens and Captain O. A. Anderson took their great stratosphere balloon with its load of scientific apparatus to the record-breaking height of 72,395 feet, and then descended safely to a gentle landing near White Lake, S. Dak. Thus, the third stratosphere expedition under the joint sponsorship of the National Geographic Society and the Army Air Corps was brought to a most successful conclusion.

During the first stratosphere flight in July, 1934, Kepner, Stevens and Ander-

son reached an altitude of about 60,600 feet when rips or tears were discovered in the bottom of the balloon, and an immediate descent was decided upon. These tears increased in size as the balloon came down, until finally the whole bottom of the bag tore away, so that the officers could look directly up into the great balloon. It thus became in effect a parachute, with the upper part filled with hydrogen gas. As the descent continued, the hydrogen became mixed with air. Through friction or some other unknown cause a spark occurred, igniting this explosive mixture, and the top of the balloon was blown to fragments. At this time the balloon was little more than half a mile above the ground, and the gondola, now without any support whatever, fell like a plummet. In the twenty seconds intervening between the explosion and the crash of the gondola in a Nebraska corn-field, Major Kepner and Captains Stevens and Anderson took to their parachutes and landed safely near the wreck of the balloon.

The examination of the fabric of the balloon after the accident showed that the tears in the bottom of the balloon resulted from the adhesion of the balloon fabric, the lower part of which had been folded back into the main body of the balloon to facilitate handling.

Undaunted by the accident to the *Explorer I*, Captains Stevens and Anderson and the sponsors for the flight undertook immediately the development of plans for a second expedition during 1935. To avoid the possibility of another explosion it was decided to use helium in place of hydrogen. Since helium is less buoyant than hydrogen, this necessitated building a larger balloon in order to attain the desired height of over 70,000 feet. The volume of the new balloon, the *Explorer II*, was accordingly increased to 3,700,000 cubic feet. The fabric was treated and the balloon folded in such a way as to eliminate dangerous adhesions. The diameter of the gondola was increased to 9 feet, thus providing more room for the equipment, and the manholes were made larger and easier to get out of in case of an emergency.

In May, 1935, the Stratocamp was again established in the bowl in the Black Hills near Rapid City, S. Dak. After weeks spent in adjusting and testing the instruments and equipment the long looked-for word was given on July 10 that the weather conditions were ideal for a flight on the following day. The inflation went off with clock-like precision, but while the gondola was being attached to the great balloon towering three hundred feet above it, there was a roar of escaping gas and the fabric of the great balloon fell in a tumbled heap over the gondola. The balloon had split across its top!

It was vitally important to determine the cause of this second failure. A searching examination of the top of the balloon showed unmistakably that the rip had started near the tip of the rip panel and had then spread throughout the top of the balloon. The rip panel is a large triangular piece of balloon fabric with reinforced edges and is used to deflate the balloon quickly when it has been brought back to the ground, the idea being to confine the tear to the edges of the rip panel and thus prevent the destruction of the whole top. This construction had been used successfully in other (smaller) stratosphere balloons. After the accident, however, it was suspected that this rip panel, designed primarily to protect the balloon, was in fact the cause of its destruction. Subsequent experiments carried out at the plant of the Goodyear Zeppelin Corporation with a huge model representing the top of the balloon showed this to be true. The reinforcing tapes of the rip panel prevented the balloon from stretching uniformly and the stresses in the fabric near the tip of the panel were found to be far greater than in other parts of the top.

—*Courtesy of National Geographic Society—Army Air Corps Stratosphere Flight*

READY FOR THE TAKE-OFF

CAPTAIN ANDERSON IS STANDING WITH ONE FOOT ON THE COIL OF DRAG-ROPE. THE LARGE BLACK BAG AT HIS LEFT CONTAINS THE 80-FOOT EMERGENCY PARACHUTE FOR THE GONDOLA. BEHIND HIM IS THE BASKET CONTAINING THE LARGE SPECTROGRAPH. THE GROUND CREW IS HOLDING THE BALLOON DOWN.

The cause of the failure had now been definitely determined. The solution was to eliminate the rip panel altogether and to use instead a long wire which would cut through the top of the balloon when the rope to which it was attached was pulled. Still determined, the National Geographic Society and the Army Air Corps decided upon a third expedition. The Goodyear Zeppelin Corporation generously volunteered to put a brand new top in the balloon without any cost whatever to the expedition. Late in September the camp was again established in the Stratobowl. It was hoped that a flight might be made early in October, but the necessary weather conditions—still air over the bowl for the take-off, cloudless skies to the east and south for 300 miles and low winds at the time of landing—did not develop until some weeks later. For the scientists and soldiers living in tents the undertaking began to assume the character of an Arctic expedition. Temperatures below zero were encountered, but the morale of the camp was unshaken, and on November 10 the looked-for day arrived.

Even this expedition was not to be without its tense moments. In introducing the helium gas into a rubberized fabric stiff with cold a pocket of gas at high pressure inadvertently formed in the lower part of the fabric and before the gas could be shut off another tear occurred. When the balloon had risen

—*Courtesy of National Geographic Society-Army Air Corps Stratosphere Flight*

OFF FOR THE STRATOSPHERE

THE GREAT BALLOON SOARS SILENTLY OVER THE RIM OF THE BOWL. THE FLOOR OF THE BOWL, WITH ITS RING OF LIGHTS, CAN BE SEEN IN THE FOREGROUND AT THE LEFT.

sufficiently to disclose the damage a tear seventeen feet long was found. In a canvas shelter supported on the backs of soldiers this tear was closed with a patch —closed so skilfully and successfully that after the flight not a trace of slippage could be found.

Except for this delay the preparations for the take-off moved forward according to schedule. But a precious hour had been lost, and at seven o'clock in the morning, when Captain Anderson gave the word, "Let go," a wind was already blowing across the top of the bowl. Here a second exciting moment occurred. The great balloon had cleared the top of the rim by 150 feet when suddenly it struck a down-draft of air which checked its flight and forced it downward toward the startled spectators below. Their consternation increased when Captain Anderson quickly released 750 pounds of ballast above them in the form of streams of fine lead shot. This loss in weight effectively stopped the descent of the balloon and started it again on its upward flight.

At 17,000 feet the manholes were closed and the gondola made airtight. The balloon then rose steadily until it reached a height of about 65,000 feet. At this altitude the helium had expanded until it completely filled the bag and was escaping through the appendices below. The great balloon had now for the first time taken on its truly spherical form. To go higher it was necessary to lighten the load, and ballast was then gradually discharged until there remained only the amount necessary for use in making a

safe descent and landing. By this time the balloon had reached a height of over 72,000 feet, where it remained an hour and a half for observations.

Most of the instruments carried were of the self-recording type. They included two spectrographs for studying the ozone content of the air; an elaborate apparatus for counting the number of cosmic rays coming in from various directions; an instrument for measuring the bursts of radiation produced by cosmic rays; an apparatus for recording the changes in the electrical conductivity of the air from the ground up to the maximum altitude; evacuated flasks for taking samples of air from the stratosphere; equipment for measuring the brightness of the sun, the sky and the earth; a recording electrical thermometer for measuring the temperature of the air; barographs for measuring the air pressure; and a vertical camera taking pictures of the earth below the balloon at uniform intervals of time, which served not only to determine the drift of the balloon at various altitudes but provided an independent check upon the altitude itself. All these instruments appear to have worked satisfactorily, but the results of the investigations will not be known until the records have been carefully studied, which in some cases may require several months.

One part of the program at the top of the flight could not be carried out as planned. The gondola had been provided with a long arm with a motor-driven propeller at its end in order that the balloon might be slowly turned about a vertical axis so that the instruments in the gondola could look out at the sky in any desired direction. At the maximum altitude reached by the *Explorer I* in

—Courtesy of National Geographic Society—Army Air Corps Stratosphere Flight

THE *EXPLORER II* FLOATS SLOWLY DOWN TO A PERFECT LANDING

—*Courtesy of the National Geographic Society-Army Air Corps Stratosphere Expedition.*

THE FLIGHT IS OVER.

CAPTAIN ANDERSON HAS JUST PULLED THE RIP CORD AND A GREAT RENT APPEARS IN THE TOP OF THE BALLOON THROUGH WHICH THE HELIUM IS ESCAPING.

1934 (61,000 feet) this propeller fan turned the balloon readily. At 72,000 feet, however, Captain Stevens found that in the rarefied air the propeller had so little to push against that the balloon remained practically motionless even when the propeller was rotating at 5,000 revolutions per minute.

The descent was uneventful and Captain Anderson brought the gondola gently to rest in an open field near White Lake, S. Dak., after a flight of about eight hours. None of the instruments or equipment was injured in any way save for the great tear across the top of the bag, which was made in deflating the balloon after landing. Even this could have been avoided had the spectators been willing to catch hold of the drag rope and anchor the balloon, as Captain Anderson implored them to do, in which case the helium could have been released gradually through the valves in the top of the balloon. But either through fear or misunderstanding the spectators left the drag rope severely alone.

LYMAN J. BRIGGS
DIRECTOR, NATIONAL BUREAU OF STANDARDS; CHAIRMAN, ADVISORY COMMITTEE, NATIONAL GEOGRAPHIC SOCIETY—ARMY AIR CORPS STRATOSPHERE EXPEDITION